DATABASE MANAGEMENT SYSTEM (20CSE5)

UNIT 1

What is Data?

Data is a collection of a distinct small unit of information. It can be used in a variety of forms like text, numbers, media, bytes, etc. it can be stored in pieces of paper or electronic memory, etc.

Word 'Data' is originated from the word 'datum' that means 'single piece of information.' It is plural of the word datum.

What is Database

The database is a collection of inter-related data which is used to retrieve, insert and delete the data efficiently. It is also used to organize the data in the form of a table, schema, views, and reports, etc.

For example: The college Database organizes the data about the admin, staff, students and faculty etc.

Using the database, you can easily retrieve, insert, and delete the information.

A **database** is an organized collection of data, so that it can be easily accessed and managed.

You can organize data into tables, rows, columns, and index it to make it easier to find relevant information.

Database handlers create a database in such a way that only one set of software program provides access of data to all the users.

The **main purpose** of the database is to operate a large amount of information by storing, retrieving, and managing data.

There are many **dynamic websites** on the World Wide Web nowadays which are handled through databases. For example, a model that checks the availability of rooms in a hotel. It is an example of a dynamic website that uses a database.

There are many **databases available** like MySQL, Sybase, Oracle, MongoDB, Informix, PostgreSQL, SQL Server, etc.

Modern databases are managed by the database management system (DBMS).

SQL or Structured Query Language is used to operate on the data stored in a database. SQL depends on relational algebra and tuple relational calculus.

A cylindrical structure is used to display the image of a database.

Database Management System

- Database management system is a software which is used to manage the database. For example: MySQL, Oracle, etc are a very popular commercial database which is used in different applications.
- DBMS provides an interface to perform various operations like database creation, storing data in it, updating data, creating a table in the database and a lot more.

In computing, Data is information that can be translated into a form for efficient movement and processing. Data is interchangeable.

Evolution of Databases

The database has completed more than 50 years of journey of its evolution from flat-file system to relational and objects relational systems. It has gone through several generations.

The Evolution

File-Based

1968 was the year when File-Based database were introduced. In file-based databases, data was maintained in a flat file. Though files have many advantages, there are several limitations.

One of the major advantages is that the file system has various access methods, e.g., sequential, indexed, and random.

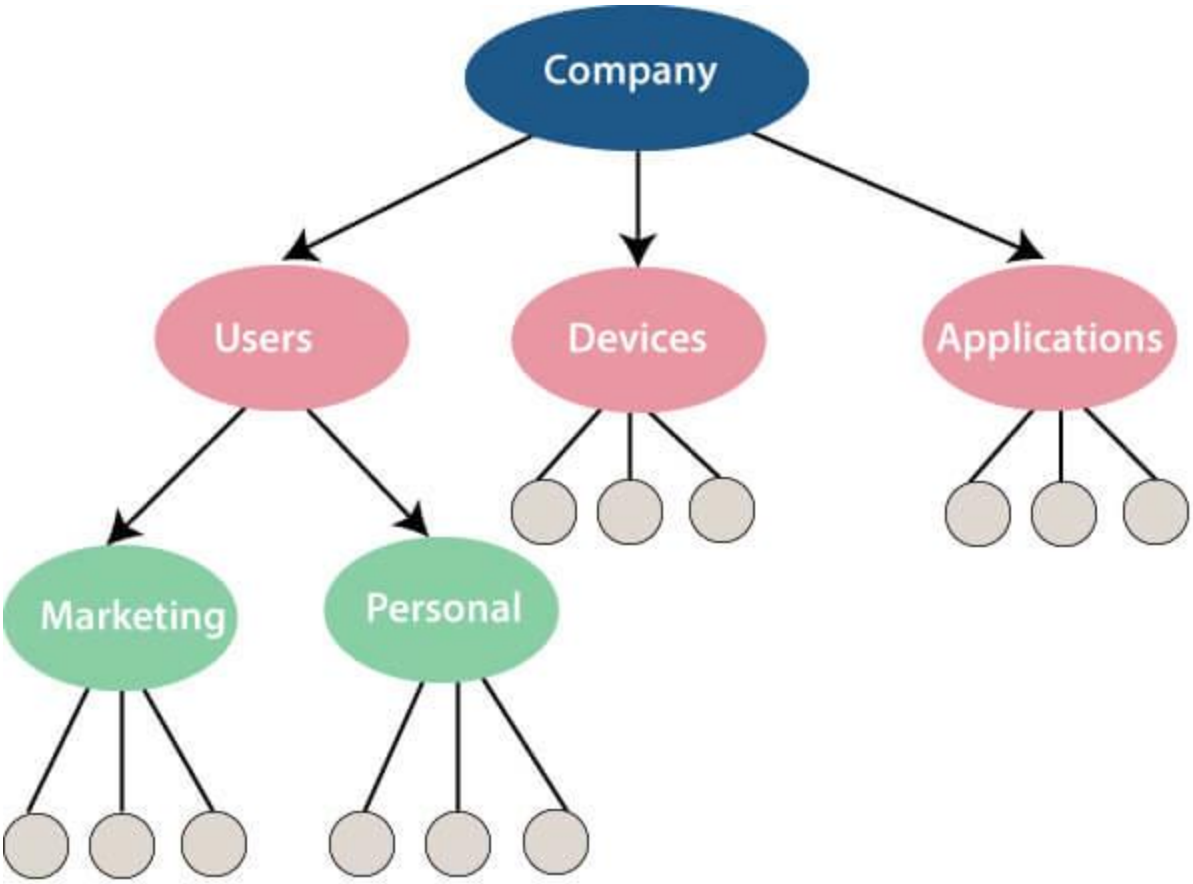
It requires extensive programming in a third-generation language such as COBOL, BASIC.

Hierarchical Data Model

1968-1980 was the era of the Hierarchical Database. Prominent hierarchical database model was IBM's first DBMS. It was called IMS (Information Management System).

In this model, files are related in a parent/child manner.

Below diagram represents Hierarchical Data Model. Small circle represents objects.



Like file system, this model also had some limitations like complex implementation, lack structural independence, can't easily handle a many-many relationship, etc.

Network data model

Charles Bachman developed the first DBMS at Honeywell called Integrated Data Store (IDS). It was developed in the early 1960s, but it was standardized in 1971 by the CODASYL group (Conference on Data Systems Languages).

In this model, files are related as owners and members, like to the common network model.

Network data model identified the following components:

- Network schema (Database organization)

- Sub-schema (views of database per user)
- Data management language (procedural)

This model also had some limitations like system complexity and difficult to design and maintain.

Relational Database

1970 - Present: It is the era of Relational Database and Database Management. In 1970, the relational model was proposed by E.F. Codd.

Relational database model has two main terminologies called instance and schema.

TABLE /RELATION :STUDENT

The instance is a table with rows or columns

Schema specifies the structure like name of the relation, type of each column and name.

This model uses some mathematical concept like set theory and predicate logic.

The first internet database application had been created in 1995.

During the era of the relational database, many more models had introduced like object-oriented model, object-relational model, etc.

Cloud database

Cloud database facilitates you to store, manage, and retrieve their structured, unstructured data via a cloud platform. This data is accessible over the Internet. Cloud databases are also called a database as service (DBaaS) because they are offered as a managed service.

Some best cloud options are:

- AWS (Amazon Web Services)

- Snowflake Computing
- Oracle Database Cloud Services
- Microsoft SQL server
- Google cloud spanner

Advantages of cloud database

Lower costs

Generally, company provider does not have to invest in databases. It can maintain and support one or more data centers.

Automated

Cloud databases are enriched with a variety of automated processes such as recovery, failover, and auto-scaling.

Increased accessibility

You can access your cloud-based database from any location, anytime. All you need is just an internet connection.

NoSQL Database

A NoSQL database is an approach to design such databases that can accommodate a wide variety of data models. NoSQL stands for "not only SQL." It is an alternative to traditional relational databases in which data is placed in tables, and data schema is perfectly designed before the database is built.

NoSQL databases are useful for a large set of distributed data.

Some examples of NoSQL database system with their category are:

- MongoDB, CouchDB, Cloudant **(Document-based)**
- Memcached, Redis, Coherence **(key-value store)**
- HBase, Big Table, Accumulo **(Tabular)**

Advantage of NoSQL

High Scalability

NoSQL can handle an extensive amount of data because of scalability. If the data grows, NoSQL database scale it to handle that data in an efficient manner.

High Availability

NoSQL supports auto replication. Auto replication makes it highly available because, in case of any failure, data replicates itself to the previous consistent state.

Disadvantage of NoSQL

Open source

NoSQL is an open-source database, so there is no reliable standard for NoSQL yet.

Management challenge

Data management in NoSQL is much more complicated than relational databases. It is very challenging to install and even more hectic to manage daily.

GUI is not available

GUI tools for NoSQL database are not easily available in the market.

Backup

Backup is a great weak point for NoSQL databases. Some databases, like MongoDB, have no powerful approaches for data backup.

The Object-Oriented Databases

The object-oriented databases contain data in the form of object and classes. Objects are the real-world entity, and types are the collection of objects. An object-oriented database is a combination of relational model features with objects oriented principles. It is an alternative implementation to that of the relational model.

Object-oriented databases hold the rules of object-oriented programming. An object-oriented database management system is a hybrid application.

The object-oriented database model contains the following properties.

Object-oriented programming properties

- Objects
- Classes
- Inheritance
- Polymorphism
- Encapsulation

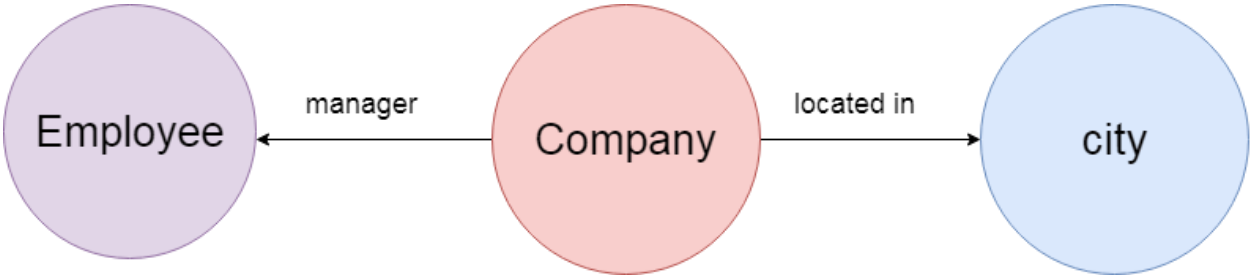
Relational database properties

- Atomicity(ABORT COMMIT)
- Consistency
- Integrity
- Durability
- Concurrency
- Query processing

Graph Databases

A graph database is a NoSQL database. It is a graphical representation of data. It contains nodes and edges. A node represents an entity, and each edge represents a relationship between two edges. Every node in a graph database represents a unique identifier.

Graph databases are beneficial for searching the relationship between data because they highlight the relationship between relevant data.



Graph databases are very useful when the database contains a complex relationship and dynamic schema.

It is mostly used in **supply chain management**, identifying the source of **IP telephony**.

DBMS (Data Base Management System)

Database management System is software which is used to store and retrieve the database. For example, Oracle, MySQL, etc.; these are some popular DBMS tools.

- DBMS provides the interface to perform the various operations like creation, deletion, modification, etc.
- DBMS allows the user to create their databases as per their requirement.
- DBMS accepts the request from the application and provides specific data through the operating system.

- DBMS contains the group of programs which acts according to the user instruction.
- It provides security to the database.

Advantage of DBMS

Controls redundancy

It stores all the data in a single database file, so it can control data redundancy.

Data sharing

An authorized user can share the data among multiple users.

Backup

It providesBackup and recovery subsystem. This recovery system creates automatic data from system failure and restores data if required.

Multiple user interfaces

It provides a different type of user interfaces like GUI, application interfaces.

Disadvantage of DBMS

Size

It occupies large disk space and large memory to run efficiently.

Cost

DBMS requires a high-speed data processor and larger memory to run DBMS software, so it is costly.

Complexity

DBMS creates additional complexity and requirements.

RDBMS (Relational Database Management System)

The word RDBMS is termed as 'Relational Database Management System.' It is represented as a table that contains rows and column.

RDBMS is based on the Relational model; it was introduced by E. F. Codd.

A relational database contains the following components:

- Table
- Record/ Tuple
- Field/Column name /Attribute
- Instance
- Schema
- Keys

An RDBMS is a tabular DBMS that maintains the security, integrity, accuracy, and consistency of the data.

- It provides protection and security to the database. In the case of multiple users, it also maintains data consistency.

DBMS allows users the following tasks:

- **Data Definition:** It is used for creation, modification, and removal of definition that defines the organization of data in the database.
- **Data Updation:** It is used for the insertion, modification, and deletion of the actual data in the database.
- **Data Retrieval:** It is used to retrieve the data from the database which can be used by applications for various purposes.
- **User Administration:** It is used for registering and monitoring users, maintain data integrity, enforcing data security, dealing with concurrency

control, monitoring performance and recovering information corrupted by unexpected failure.

Characteristics of DBMS

- It uses a digital repository established on a server to store and manage the information.
- It can provide a clear and logical view of the process that manipulates data.
- DBMS contains automatic backup and recovery procedures.
- It contains ACID properties which maintain data in a healthy state in case of failure.
- It can reduce the complex relationship between data.
- It is used to support manipulation and processing of data.
- It is used to provide security of data.
- It can view the database from different viewpoints according to the requirements of the user.

Advantages of DBMS

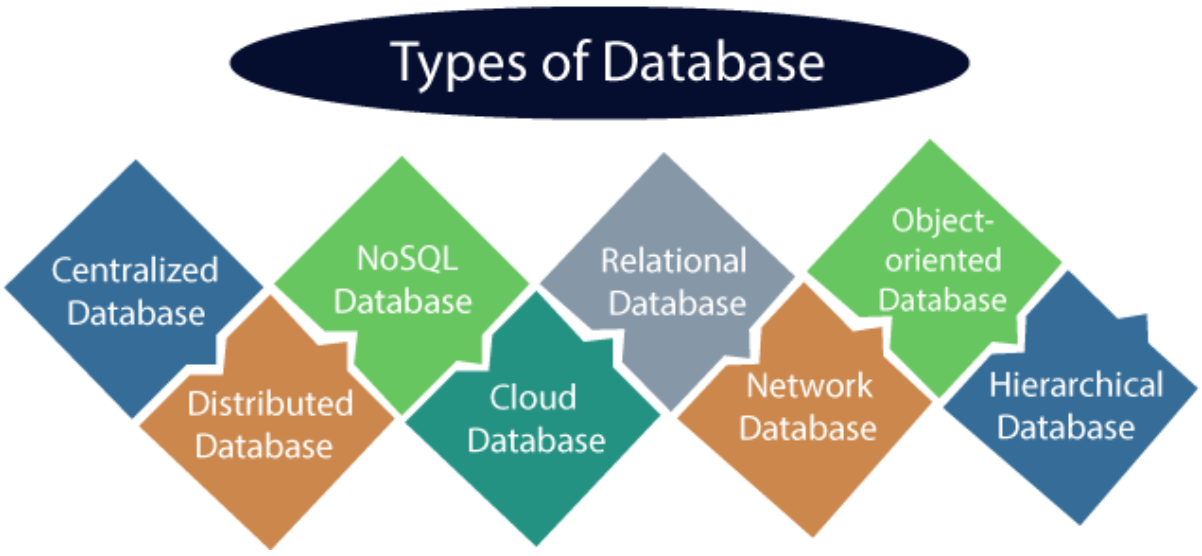
- **Controls database redundancy:** It can control data redundancy because it stores all the data in one single database file and that recorded data is placed in the database.
- **Data sharing:** In DBMS, the authorized users of an organization can share the data among multiple users.
- **Easily Maintenance:** It can be easily maintainable due to the centralized nature of the database system.
- **Reduce time:** It reduces development time and maintenance need.
- **Backup:** It provides backup and recovery subsystems which create automatic backup of data from hardware and software failures and restores the data if required.
- **multiple user interface:** It provides different types of user interfaces like graphical user interfaces, application program interfaces

Disadvantages of DBMS

- **Cost of Hardware and Software:** It requires a high speed of data processor and large memory size to run DBMS software.
- **Size:** It occupies a large space of disks and large memory to run them efficiently.
- **Complexity:** Database system creates additional complexity and requirements.
- **Higher impact of failure:** Failure is highly impacted the database because in most of the organization, all the data stored in a single database and if the database is damaged due to electric failure or database corruption then the data may be lost forever.

Types of Database

There are various types of databases used for storing different varieties of data:



1) Centralized Database: It is the type of database that stores data at a centralized database system. It comforts the users to access the stored data from different locations through several applications. These applications contain the authentication process to let users access data securely. An example of a

Centralized database can be Central Library that carries a central database of each library in a college/university.

Advantages of Centralized Database

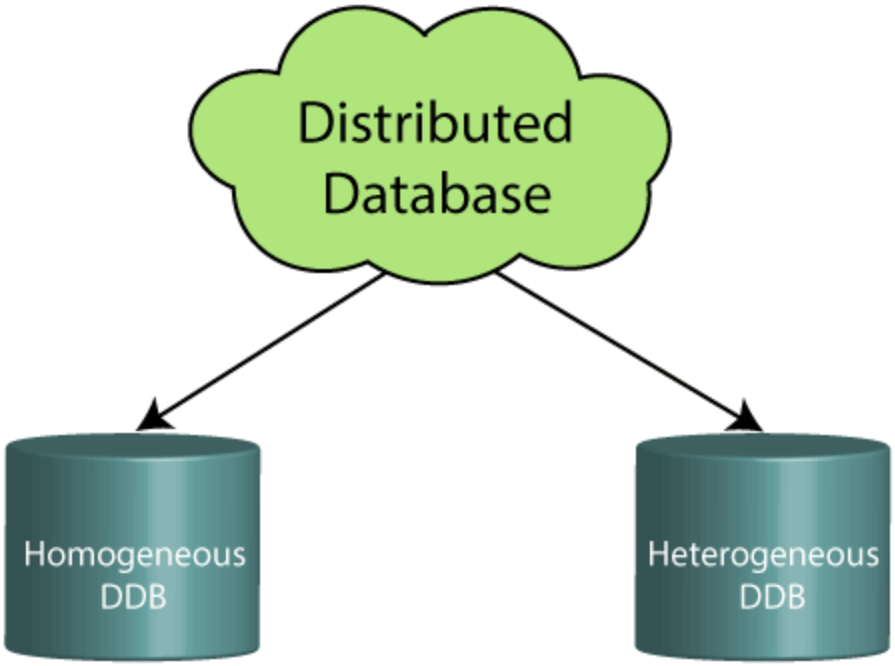
- It has decreased the risk of data management, i.e., manipulation of data will not affect the core data.
- Data consistency is maintained as it manages data in a central repository.
- It provides better data quality, which enables organizations to establish data standards.
- It is less costly because fewer vendors are required to handle the data sets.

Disadvantages of Centralized Database

- The size of the centralized database is large, which increases the response time for fetching the data.
- It is not easy to update such an extensive database system.
- If any server failure occurs, entire data will be lost, which could be a huge loss.

2) Distributed Database: Unlike a centralized database system, in distributed systems, data is distributed among different database systems of an organization. These database systems are connected via communication links. Such links help the end-users to access the data easily. **Examples** of the Distributed database are Apache Cassandra, HBase, Ignite, etc.

We can further divide a distributed database system into:



- **Homogeneous DDB:** Those database systems which execute on the same operating system and use the same application process and carry the same hardware devices.
- **Heterogeneous DDB:** Those database systems which execute on different operating systems under different application procedures, and carries different hardware devices.

Advantages of Distributed Database

- Modular development is possible in a distributed database, i.e., the system can be expanded by including new computers and connecting them to the distributed system.
- One server failure will not affect the entire data set.

3) Relational Database: This database is based on the relational data model, which stores data in the form of rows(tuple) and columns(attributes), and together forms a table(relation). A relational database uses SQL for storing, manipulating, as well as maintaining the data. E.F. Codd invented the database in 1970. Each table in the database carries a key that makes the data unique from others. **Examples** of Relational databases are MySQL, Microsoft SQL Server, Oracle, etc.

Properties of Relational Database

There are following four commonly known properties of a relational model known as ACID properties, where:

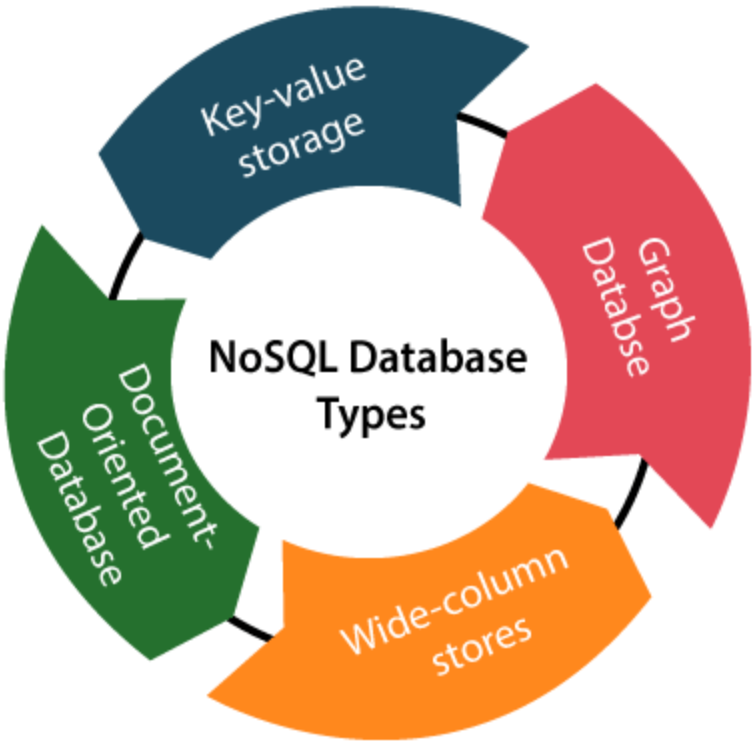
A means Atomicity: This ensures the data operation will complete either with success or with failure. It follows the 'all or nothing' strategy. For example, a transaction will either be committed or will abort.

C means Consistency: If we perform any operation over the data, its value before and after the operation should be preserved. For example, the account balance before and after the transaction should be correct, i.e., it should remain conserved.

I means Isolation: There can be concurrent users for accessing data at the same time from the database. Thus, isolation between the data should remain isolated. For example, when multiple transactions occur at the same time, one transaction effects should not be visible to the other transactions in the database.

D means Durability: It ensures that once it completes the operation and commits the data, data changes should remain permanent.

4) NoSQL Database: Non-SQL/Not Only SQL is a type of database that is used for storing a wide range of data sets. It is not a relational database as it stores data not only in tabular form but in several different ways. It came into existence when the demand for building modern applications increased. Thus, NoSQL presented a wide variety of database technologies in response to the demands. We can further divide a NoSQL database into the following four types:



a. **Key-value storage:** It is the simplest type of database storage where it stores every single item as a key (or attribute name) holding its value, together.

b. **Document-oriented Database:** A type of database used to store data as JSON-like document. It helps developers in storing data by using the same document-model format as used in the application code.

c. **Graph Databases:** It is used for storing vast amounts of data in a graph-like structure. Most commonly, social networking websites use the graph database.

d. **Wide-column stores:** It is similar to the data represented in relational databases. Here, data is stored in large columns together, instead of storing in rows.

Advantages of NoSQL Database

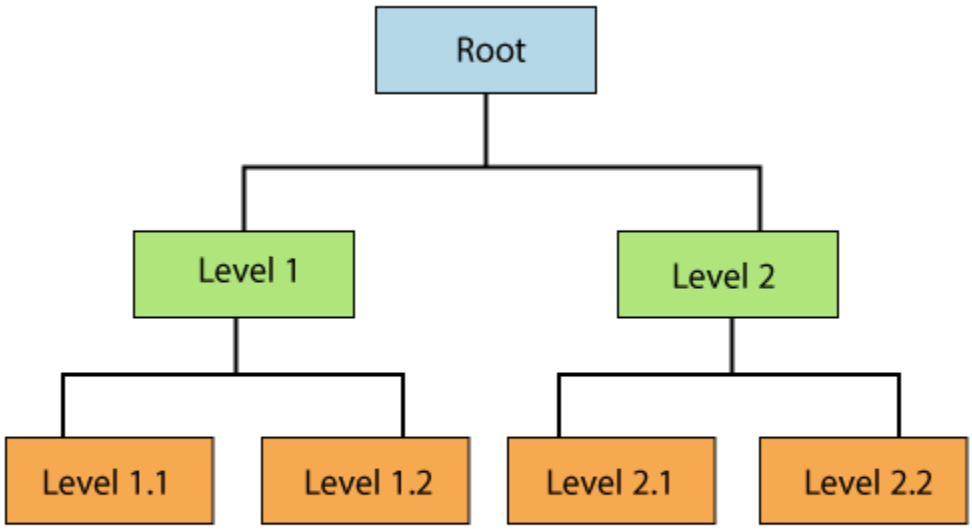
- It enables good productivity in the application development as it is not required to store data in a structured format.
- It is a better option for managing and handling large data sets.
- It provides high scalability.
- Users can quickly access data from the database through key-value.

5) Cloud Database: A type of database where data is stored in a virtual environment and executes over the cloud computing platform. It provides users with various cloud computing services (SaaS, PaaS, IaaS, etc.) for accessing the database. There are numerous cloud platforms, but the best options are:

- Amazon Web Services(AWS)
- Microsoft Azure
- Kamatera
- PhonixNAP
- ScienceSoft
- Google Cloud SQL, etc.

6) Object-oriented Databases: The type of database that uses the object-based data model approach for storing data in the database system. The data is represented and stored as objects which are similar to the objects used in the object-oriented programming language.

7) Hierarchical Databases: It is the type of database that stores data in the form of parent-children relationship nodes. Here, it organizes data in a tree-like structure.



Hierarchical Database

Data get stored in the form of records that are connected via links. Each child record in the tree will contain only one parent. On the other hand, each parent record can have multiple child records.

8) Network Databases: It is the database that typically follows the network data model. Here, the representation of data is in the form of nodes connected via links between them. Unlike the hierarchical database, it allows each record to have multiple children and parent nodes to form a generalized graph structure.

9) Personal Database: Collecting and storing data on the user's system defines a Personal Database. This database is basically designed for a single user.

Advantage of Personal Database

- It is simple and easy to handle.
- It occupies less storage space as it is small in size.

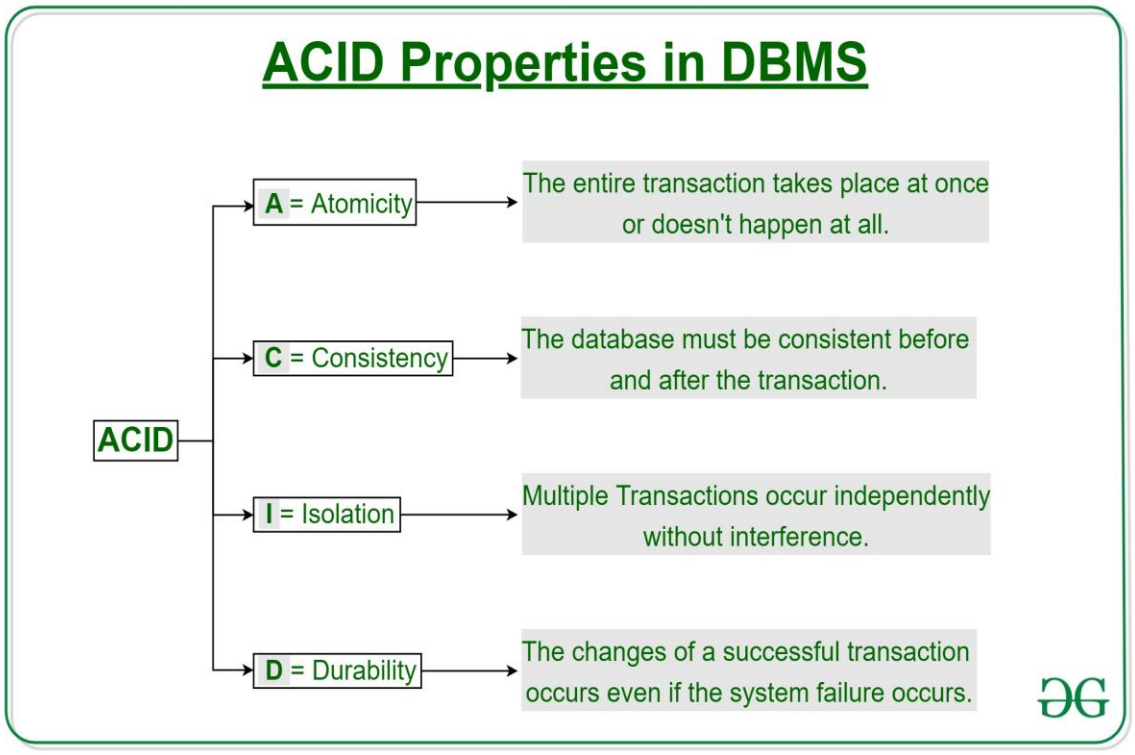
10) Operational Database: The type of database which creates and updates the database in real-time. It is basically designed for executing and handling the daily data operations in several businesses. For example, An organization uses operational databases for managing per day transactions.

11) Enterprise Database: Large organizations or enterprises use this database for managing a massive amount of data. It helps organizations to increase and improve their efficiency. Such a database allows simultaneous access to users.

Advantages of Enterprise Database:

- Multi processes are supportable over the Enterprise database.
- It allows executing parallel queries on the system.

ACID Properties in DBMS: A **transaction** is a single logical unit of work which accesses and possibly modifies the contents of a database. Transactions access data using read and write operations.
In order to maintain consistency in a database, before and after the transaction, certain properties are followed. These are called **ACID** properties.



ACID Properties in DBMS:

Atomicity

By this, we mean that either the entire transaction takes place at once or doesn't happen at all. There is no midway i.e. transactions do not occur partially. Each transaction is considered as one unit and either runs to completion or is not executed at all. It involves the following two operations.

—**Abort**: If a transaction aborts, changes made to database are not visible.

—**Commit**: If a transaction commits, changes made are visible.

Atomicity is also known as the 'All or nothing rule'.

Consider the following transaction **T** consisting of **T1** and **T2**: Transfer of 100 from account **X** to account **Y**.

Before: X : 500	Y: 200
Transaction T	
T1	**T2**
Read (X) X: = X – 100 Write (X)	Read (Y) Y: = Y + 100 Write (Y)
After: X : 400	Y : 300

If the transaction fails after completion of **T1** but before completion of **T2**.(say, after **write(X)** but before **write(Y)**), then amount has been deducted from **X** but not added to **Y**. This results in an inconsistent database state. Therefore, the transaction must be executed in entirety in order to ensure correctness of database state.

Consistency

This means that integrity constraints must be maintained so that the database is consistent before and after the transaction. It refers to the correctness of a database. Referring to the example above,
The total amount before and after the transaction must be maintained.
Total **before T** occurs = **500 + 200 = 700**.
Total **after T occurs** = **400 + 300 = 700**.
Therefore, database is **consistent**. Inconsistency occurs in case **T1** completes but **T2** fails. As a result T is incomplete.

Isolation

This property ensures that multiple transactions can occur concurrently without leading to the inconsistency of database state. Transactions occur independently without interference. Changes occurring in a particular transaction will not be visible to any other transaction until that particular change in that transaction is written to memory or has been committed. This property ensures that the execution of transactions concurrently will result in a state that is equivalent to a state achieved these were executed serially in some order.
Let **X**= 500, **Y** = 500.
Consider two transactions **T** and **T".**

T	T''
Read (X) X: = X*100 Write (X) Read (Y) Y: = Y – 50 Write	Read (X) Read (Y) Z: = X + Y Write (Z)

Suppose **T** has been executed till **Read (Y)** and then **T''** starts. As a result , interleaving of operations takes place due to which **T''** reads correct value of **X** but incorrect value of **Y** and sum computed by
T'': (X+Y = 50, 000+500=50, 500)
is thus not consistent with the sum at end of transaction:
T: (X+Y = 50, 000 + 450 = 50, 450).
This results in database inconsistency, due to a loss of 50 units. Hence, transactions must take place in isolation and changes should be visible only after they have been made to the main memory.

Durability:
This property ensures that once the transaction has completed execution, the updates and modifications to the database are stored in and written to disk and they persist even if a system failure occurs. These updates now become permanent and are stored in non-volatile memory. The effects of the transaction, thus, are never lost.

RDBMS (Relational Database Management System)

The word RDBMS is termed as 'Relational Database Management System.' It is represented as a table that contains rows and column.

RDBMS is based on the Relational model; it was introduced by E. F. Codd.

RDBMS stands for *Relational Database Management Systems*..

All modern database management systems like SQL, MS SQL Server, IBM DB2, ORACLE, My-SQL and Microsoft Access are based on RDBMS.

It is called Relational Data Base Management System (RDBMS) because it is based on relational model introduced by E.F. Codd

How it works

Data is represented in terms of tuples (rows) in RDBMS.

Relational database is most commonly used database. It contains number of tables and each table has its own primary key.

Due to a collection of organized set of tables, data can be accessed easily in RDBMS.

Brief History of RDBMS

During 1970 to 1972, E.F. Codd published a paper to propose the use of relational database model.

RDBMS is originally based on that E.F. Codd's relational model invention.

A relational database contains the following components:

- Table
- Record/ Tuple
- Field/Column name /Attribute
- Instance
- Schema
- Keys

An RDBMS is a tabular DBMS that maintains the security, integrity, accuracy, and consistency of the data.

It provides protection and security to the database. In the case of multiple users, it also maintains data consistency.

Relational Model Concepts

- **Attribute:** Each column in a Table. Attributes are the properties which define a relation. e.g., Student_Rollno, NAME,etc.
- **Tables** – In the Relational model the, relations are saved in the table format. It is stored along with its entities. A table has two properties rows and columns. Rows represent records and columns represent attributes.
- **Tuple** – It is nothing but a single row of a table, which contains a single record.
- **Relation Schema:** A relation schema represents the name of the relation with its attributes.
- **Degree:** The total number of attributes which in the relation is called the degree of the relation.
- **Cardinality:** Total number of rows present in the Table.
- **Column:** The column represents the set of values for a specific attribute.
- **Relation instance** – Relation instance is a finite set of tuples in the RDBMS system. Relation instances never have duplicate tuples.
- **Relation key** - Every row has one, two or multiple attributes, which is called relation key.
- **Attribute domain** – Every attribute has some pre-defined value and scope which is known as attribute domain

What is a table?

The data in an RDBMS is stored in database objects which are called as **tables**. This table is basically a collection of related data entries and it consists of numerous columns and rows.

Remember, a table is the most common and simplest form of data storage in a relational database. The following program is an example of a CUSTOMERS table –

```
+----+----------+-----+-----------+----------+
| ID | NAME     | AGE | ADDRESS   | SALARY   |
+----+----------+-----+-----------+----------+
| 1 | Ramesh   | 32 | Ahmedabad |  2000.00
1 |
| 2 | Khilan   | 25 | Delhi     | 1500.00 |
| 3 | kaushik  | 23 | Kota      | 2000.00 |
| 4 | Chaitali | 25 | Mumbai    | 6500.00 |
| 5 | Hardik   | 27 | Bhopal    | 8500.00 |
```

```
| 6 | Komal    | 22 | MP        | 4500.00 |
| 7 | Muffy    | 24 | Indore    | 10000.00 |
+----+----------+-----+-----------+----------+
```

Let's see the example of student table.

ID	Name	AGE	COURSE
1	Ajeet	24	B.Tech
2	aryan	20	C.A
3	Mahesh	21	BCA
4	Ratan	22	MCA
5	Vimal	26	BSC

What is field

Every table is broken up into smaller entities called fields. The fields in the CUSTOMERS table consist of ID, NAME, AGE, ADDRESS and SALARY.

A field is a column in a table that is designed to maintain specific information about every record in the table.

In the above example OF STUDENT TABLE the field in the student table consist of id, name, age, course.

What is row or record

A row of a table is also called record. It contains the specific information of each individual entry in the table. It is a horizontal entity in the table. For example: The above table contains 5 records.

Let's see one record/row in the table.

1	Ajeet	24	B.Tech

What is column

A column is a vertical entity in the table which contains all information associated with a specific field in a table. For example: "name" is a column in the above table which contains all information about student's name.

Ajeet
Aryan
Mahesh
Ratan
Vimal
KK

For example, a column in the CUSTOMERS table is ADDRESS, which represents location description and would be as shown below −

```
+-----------+
| ADDRESS   |
+-----------+
```

```
| Ahmedabad |
| Delhi     |
| Kota      |
| Mumbai    |
| Bhopal    |
| MP        |
| Indore    |
+----+------+
```

NULL Values

The NULL value of the table specifies that the field has been left blank during record creation. It is totally different from the value filled with zero or a field that contains space.

Data Integrity

There are the following categories of data integrity exist with each RDBMS:

Entity integrity: It specifies that there should be no duplicate rows in a table.

Domain integrity: It enforces valid entries for a given column by restricting the type, the format, or the range of values.

Referential integrity: It specifies that rows cannot be deleted, which are used by other records.

STUDENT(STUDENT-ID, NAME, DEPART-NAME)

DEPARTMENT (DEPT-NO,DEPART NAME,STUDENT ENROLLED)

User-defined integrity: It enforces some specific business rules that are defined by users. These rules are different from entity, domain or referential integrity.

Difference between DBMS and RDBMS

Although DBMS and RDBMS both are used to store information in physical database but there are some remarkable differences between them.

The main differences between DBMS and RDBMS are given below:

	DBMS	RDBMS
1)	DBMS applications store **data as file**.	RDBMS applications store **data in a tabular form**.
2)	In DBMS, data is generally stored in either a hierarchical form or a navigational form.	In RDBMS, the tables have an identifier called primary key and the data values are stored in the form of tables.
3)	**Normalization is not** present in DBMS.	**Normalization is** present in RDBMS.
4)	DBMS does **not apply any security** with regards to data manipulation.	RDBMS **defines the integrity constraint** for the purpose of ACID (Atomcity, Consistency, Isolation and Durability) property.
5)	DBMS uses file system to store data, so there will be **no relation between the tables**.	in RDBMS, data values are stored in the form of tables, so a **relationship** between these data values will be stored in the form of a table as well.
6)	DBMS has to provide some uniform methods to access the stored information.	RDBMS system supports a tabular structure of t data and a relationship between them to access the stored information.

7)	DBMS **does not support distributed database**.	RDBMS **supports distributed database**.
8)	DBMS is meant to be for small organization and **deal with small data**. it supports **single user**.	RDBMS is designed to **handle large amount of** it supports **multiple users**.
9)	Examples of DBMS are file systems, **xml** etc.	Example of RDBMS are **mysql**, **postgre**, **sql server**, **oracle** etc.

DBMS vs. File System

There are following differences between DBMS and File system:

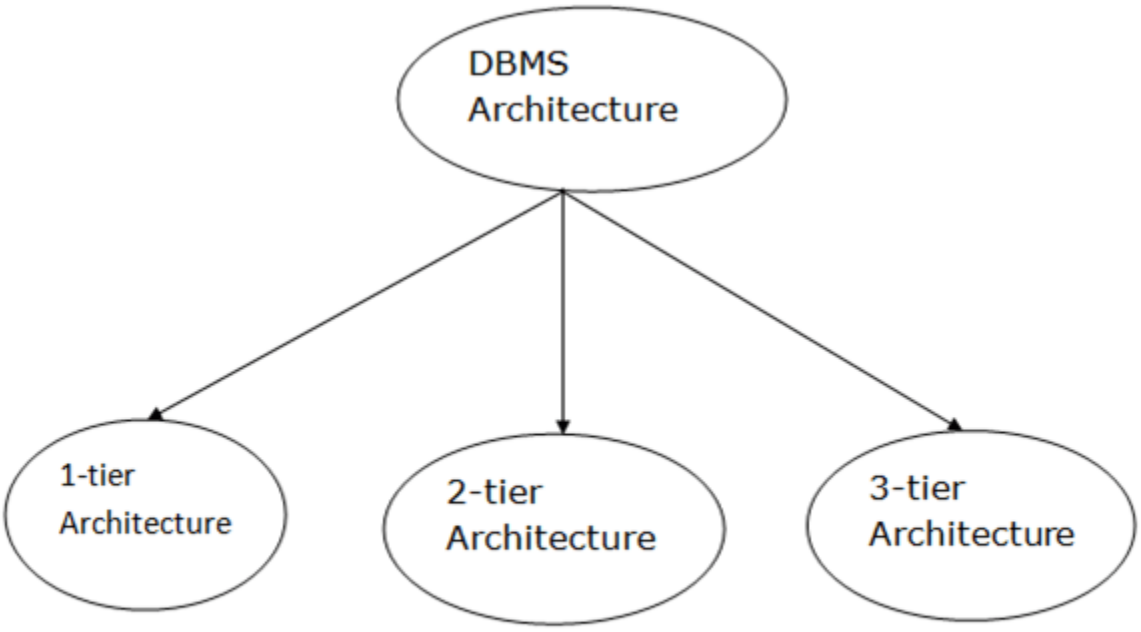
DBMS	File System
DBMS is a collection of data. In DBMS, the user is not required to write the procedures.	File system is a collection of data . In this system, the user has to write the procedures for managing the database.
DBMS gives an abstract view of data that hides the details.	File system provides the detail of the data representation and storage of data.

DBMS provides a crash recovery mechanism, i.e., DBMS protects the user from the system failure.	File system doesn't have a crash mechanism, i.e., if the system crashes while entering some data then the content of the file will lost.
DBMS provides a good protection mechanism.	It is very difficult to protect a file under the file system.
DBMS contains a wide variety of sophisticated techniques to store and retrieve the data.	File system can't efficiently store and retrieve the data.
DBMS takes care of Concurrent access of data using some form of locking.	In the File system, concurrent access has many problems like redirecting the file while deleting some information or updating some information.

DBMS Architecture

- The DBMS design depends upon its architecture. The basic client/server architecture is used to deal with a large number of PCs, web servers, database servers and other components that are connected with networks.
- The client/server architecture consists of many PCs and a workstation which are connected via the network.
- DBMS architecture depends upon how users are connected to the database to get their request done.

Types of DBMS Architecture



Database architecture can be seen as a single tier or multi-tier. But logically, database architecture is of two types like: **2-tier architecture** and **3-tier architecture**.

1-Tier Architecture

- In this architecture, the database is directly available to the user. It means the user can directly sit on the DBMS and uses it.
- Any changes done here will directly be done on the database itself. It doesn't provide a handy tool for end users.
- The 1-Tier architecture is used for development of the local application, where programmers can directly communicate with the database for the quick response.

2-Tier Architecture

- The 2-Tier architecture is same as basic client-server. In the two-tier architecture, applications on the client end can directly communicate with the database at the server side. For this interaction, API's like: **ODBC**, **JDBC** are used.
- The user interfaces and application programs are run on the client-side.
- The server side is responsible to provide the functionalities like: query processing and transaction management.
- To communicate with the DBMS, client-side application establishes a connection with the server side.

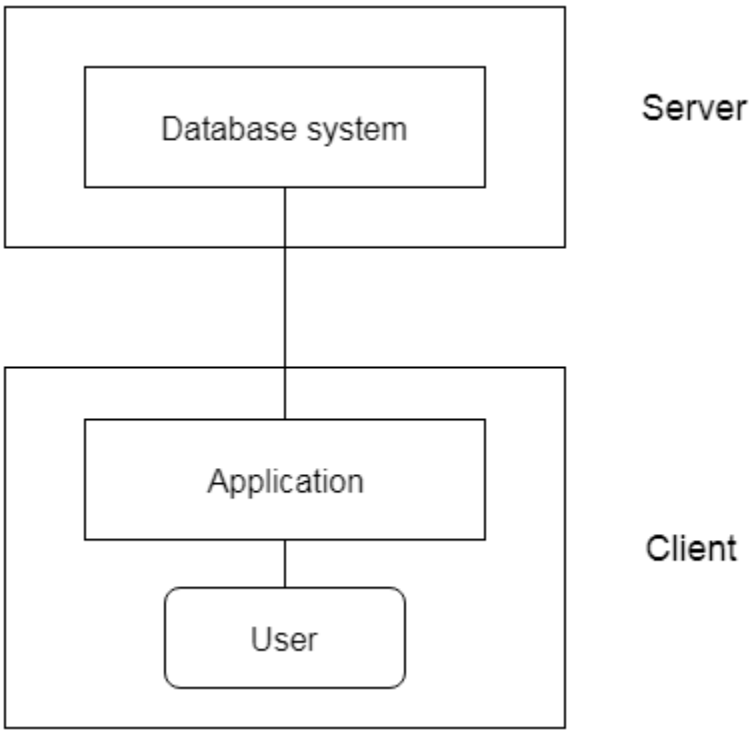


Fig: 2-tier Architecture

SQL(QUERY LANGUAGE)

3-Tier Architecture

- The 3-Tier architecture contains another layer between the client and server. In this architecture, client can't directly communicate with the server.
- The application on the client-end interacts with an application server which further communicates with the database system.
- End user has no idea about the existence of the database beyond the application server. The database also has no idea about any other user beyond the application.
- The 3-Tier architecture is used in case of large web application.

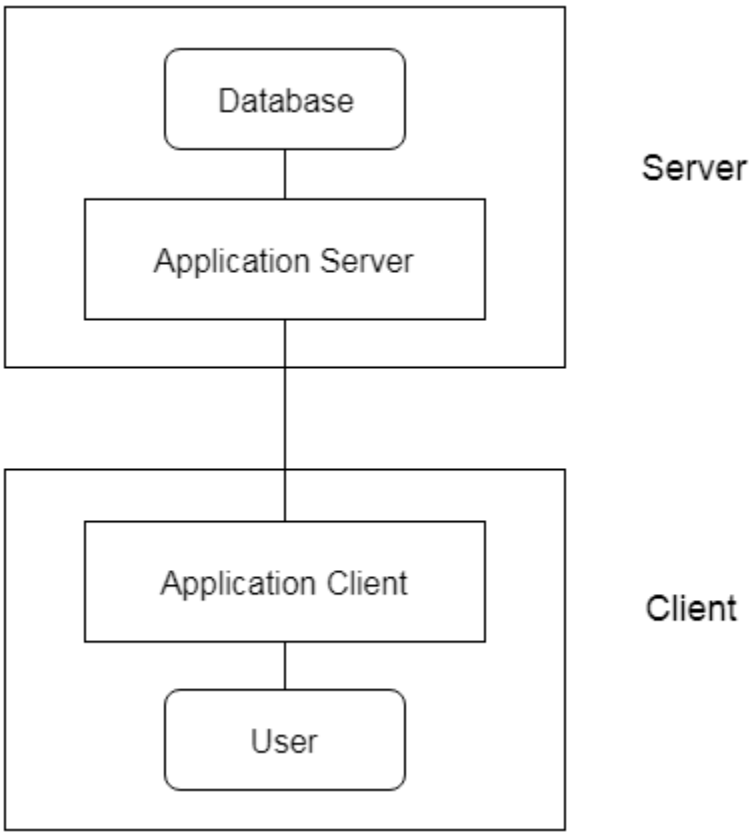
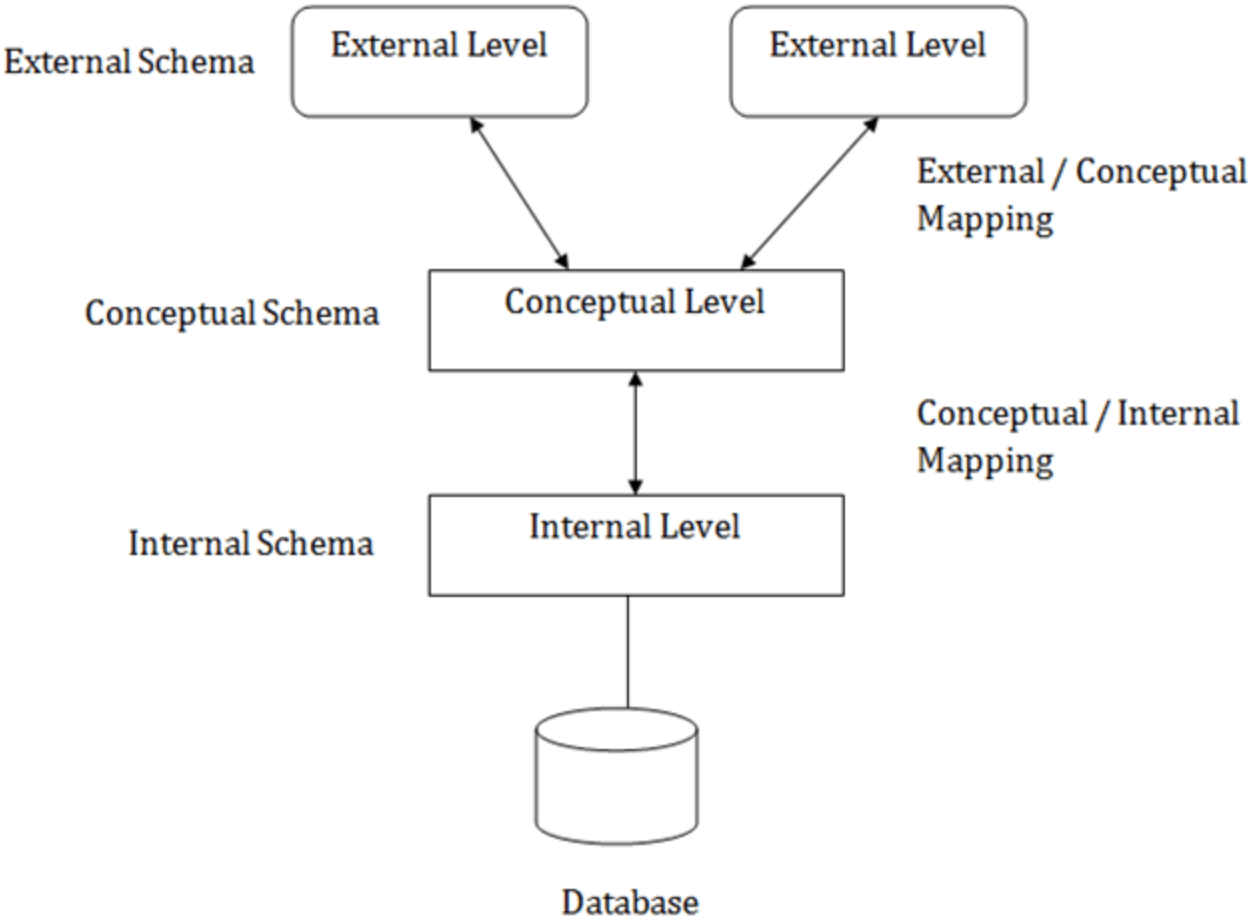


Fig: 3-tier Architecture

Three schema Architecture

- The three schema architecture is also called ANSI/SPARC architecture or three-level architecture.
- This framework is used to describe the structure of a specific database system.
- The three schema architecture is also used to separate the user applications and physical database.
- The three schema architecture contains three-levels. It breaks the database down into three different categories.

The three-schema architecture is as follows:



In the above diagram:

- It shows the DBMS architecture.
- Mapping is used to transform the request and response between various database levels of architecture.
- Mapping is not good for small DBMS because it takes more time.
- In External / Conceptual mapping, it is necessary to transform the request from external level to conceptual schema.
- In Conceptual / Internal mapping, DBMS transform the request from the conceptual to internal level.

1. Internal Level

- The internal level has an internal schema which describes the physical storage structure of the database.
- The internal schema is also known as a physical schema.

- It uses the physical data model. It is used to define that how the data will be stored in a block.
- The physical level is used to describe complex low-level data structures in detail.

2. Conceptual Level

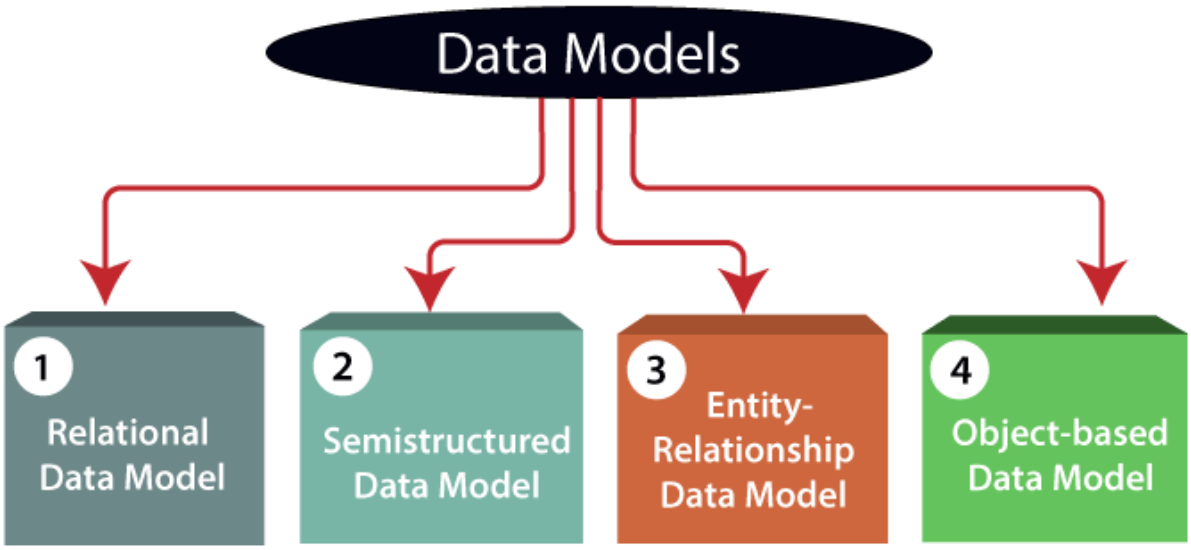
- The conceptual schema describes the design of a database at the conceptual level. Conceptual level is also known as logical level.
- The conceptual schema describes the structure of the whole database.
- The conceptual level describes what data are to be stored in the database and also describes what relationship exists among those data.
- In the conceptual level, internal details such as an implementation of the data structure are hidden.
- Programmers and database administrators work at this level.

3. External Level

- At the external level, a database contains several schemas that sometimes called as subschema. The subschema is used to describe the different view of the database.
- An external schema is also known as view schema.
- Each view schema describes the database part that a particular user group is interested and hides the remaining database from that user group.
- The view schema describes the end user interaction with database systems.

Data Models

Data Model is the modeling of the data description, data semantics, and consistency constraints of the data. It provides the conceptual tools for describing the design of a database at each level of data abstraction. Therefore, there are following four data models used for understanding the structure of the database:



1) Relational Data Model: This type of model designs the data in the form of rows and columns within a table. Thus, a relational model uses tables for representing data and in-between relationships. Tables are also called relations. This model was initially described by Edgar F. Codd, in 1969. The relational data model is the widely used model which is primarily used by commercial data processing applications.

2) Entity-Relationship Data Model: An ER model is the logical representation of data as objects and relationships among them. These objects are known as entities, and relationship is an association among these entities. This model was designed by Peter Chen and published in 1976 papers. It was widely used in database designing. A set of attributes describe the entities. For example, student_name, student_id describes the 'student' entity. A set of the same type of entities is known as an 'Entity set', and the set of the same type of relationships is known as 'relationship set'.

3) Object-based Data Model: An extension of the ER model with notions of functions, encapsulation, and object identity, as well. This model supports a rich type system that includes structured and collection types. Thus, in 1980s, various database systems following the object-oriented approach were developed. Here, the objects are nothing but the data carrying its properties.

4) Semistructured Data Model: This type of data model is different from the other three data models (explained above). The semistructured data model allows the data specifications at places where the individual data items of the same type

may have different attributes sets. The Extensible Markup Language, also known as XML, is widely used for representing the semistructured data. Although XML was initially designed for including the markup information to the text document, it gains importance because of its application in the exchange of data.

Data model Schema and Instance

- The data which is stored in the database at a particular moment of time is called an instance of the database.
- The overall design of a database is called schema.
- A database schema is the skeleton structure of the database. It represents the logical view of the entire database.
- A schema contains schema objects like table, foreign key, primary key, views, columns, data types, stored procedure, etc.
- A database schema can be represented by using the visual diagram. That diagram shows the database objects and relationship with each other.
- A database schema is designed by the database designers to help programmers whose software will interact with the database. The process of database creation is called data modeling.

A schema diagram can display only some aspects of a schema like the name of record type, data type, and constraints. Other aspects can't be specified through the schema diagram. For example, the given figure neither show the data type of each data item nor the relationship among various files.

In the database, actual data changes quite frequently. For example, in the given figure, the database changes whenever we add a new grade or add a student. The data at a particular moment of time is called the instance of the database.

STUDENT

Name	Student_number	Class	Major

COURSE

Course_name	Course_number	Credit_hours	Department

PREREQUISITE

Course_number	Prerequisite_number

SECTION

Section_identifier	Course_number	Semester	Year	Instructor

GRADE_REPORT

Student_number	Section_identifier	Grade

Data Independence

- Data independence can be explained using the three-schema architecture.
- Data independence refers characteristic of being able to modify the schema at one level of the database system without altering the schema at the next higher level.

There are two types of data independence:

1. Logical Data Independence

- Logical data independence refers characteristic of being able to change the conceptual schema without having to change the external schema.
- Logical data independence is used to separate the external level from the conceptual view.
- If we do any changes in the conceptual view of the data, then the user view of the data would not be affected.
- Logical data independence occurs at the user interface level.

2. Physical Data Independence

- Physical data independence can be defined as the capacity to change the internal schema without having to change the conceptual schema.
- If we do any changes in the storage size of the database system server, then the Conceptual structure of the database will not be affected.
- Physical data independence is used to separate conceptual levels from the internal levels.
- Physical data independence occurs at the logical interface level.

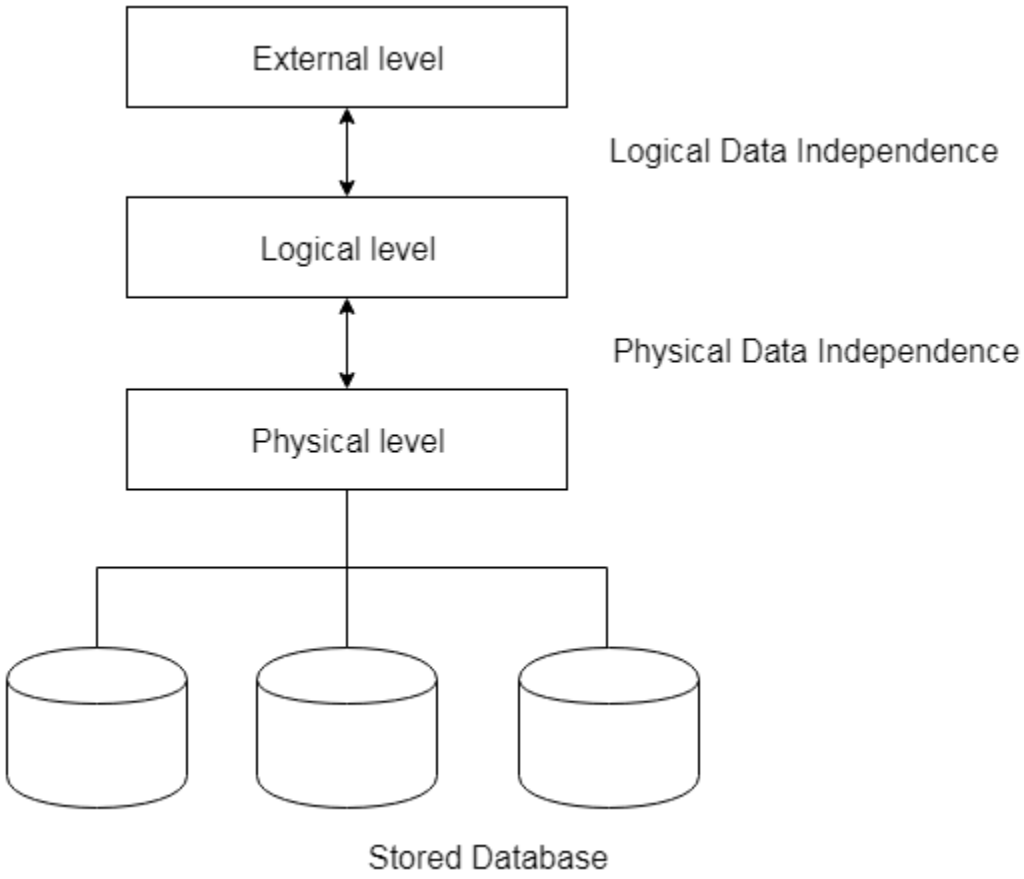


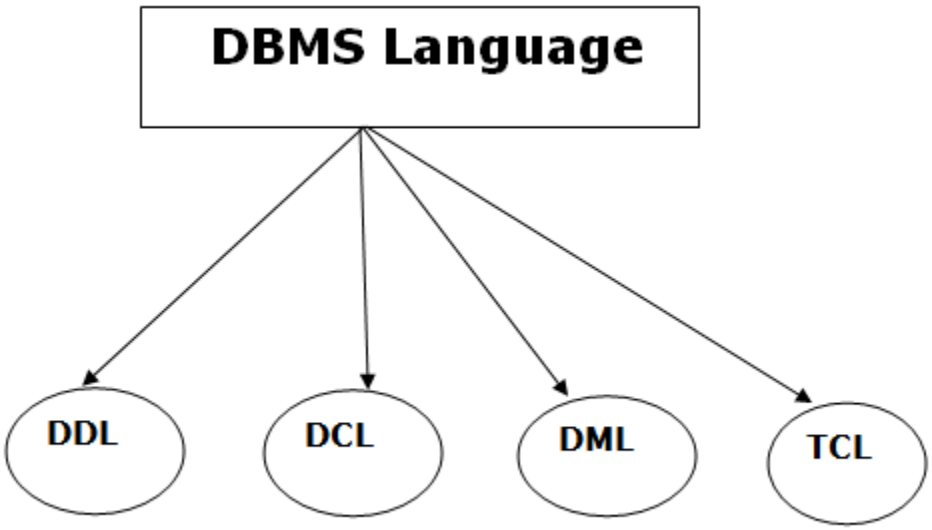
Fig: Data Independence

Database Language

- A DBMS has appropriate languages and interfaces to express database queries and updates.

- Database languages can be used to read, store and update the data in the database.

Types of Database Language



1. Data Definition Language

- **DDL** stands for **D**ata **D**efinition **L**anguage. It is used to define database structure or pattern.
- It is used to create schema, tables, indexes, constraints, etc. in the database.
- Using the DDL statements, you can create the skeleton of the database.
- Data definition language is used to store the information of metadata like the number of tables and schemas, their names, indexes, columns in each table, constraints, etc.

Here are some tasks that come under DDL:

- **Create:** It is used to create objects in the database.
- **Alter:** It is used to alter the structure of the database.
- **Drop:** It is used to delete objects from the database.
- **Truncate:** It is used to remove all records from a table.
- **Rename:** It is used to rename an object.

- **Comment:** It is used to comment on the data dictionary.

These commands are used to update the database schema that's why they come under Data definition language.

2. Data Manipulation Language

DML stands for **D**ata **M**anipulation **L**anguage. It is used for accessing and manipulating data in a database. It handles user requests.

Here are some tasks that come under DML:

- **Select:** It is used to retrieve data from a database.
- **Insert:** It is used to insert data into a table.
- **Update:** It is used to update existing data within a table.
- **Delete:** It is used to delete all records from a table.
- **Merge:** It performs UPSERT operation, i.e., insert or update operations.
- **Call:** It is used to call a structured query language or a Java subprogram.
- **Explain Plan:** It has the parameter of explaining data.
- **Lock Table:** It controls concurrency.

3. Data Control Language

- **DCL** stands for **D**ata **C**ontrol **L**anguage. It is used to retrieve the stored or saved data.
- The DCL execution is transactional. It also has rollback parameters.

  (But in Oracle database, the execution of data control language does not have the feature of rolling back.)

Here are some tasks that come under DCL:

- **Grant:** It is used to give user access privileges to a database.
- **Revoke:** It is used to take back permissions from the user.

There are the following operations which have the authorization of Revoke:

CONNECT, INSERT, USAGE, EXECUTE, DELETE, UPDATE and SELECT.

4. Transaction Control Language

TCL is used to run the changes made by the DML statement. TCL can be grouped into a logical transaction.

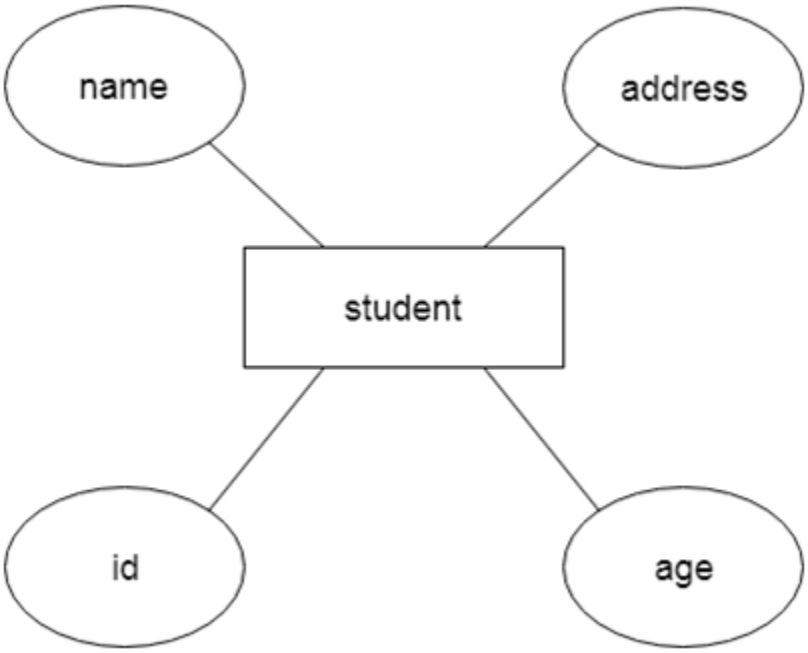
Here are some tasks that come under TCL:

- **Commit:** It is used to save the transaction on the database.
- **Rollback:** It is used to restore the database to original since the last Commit

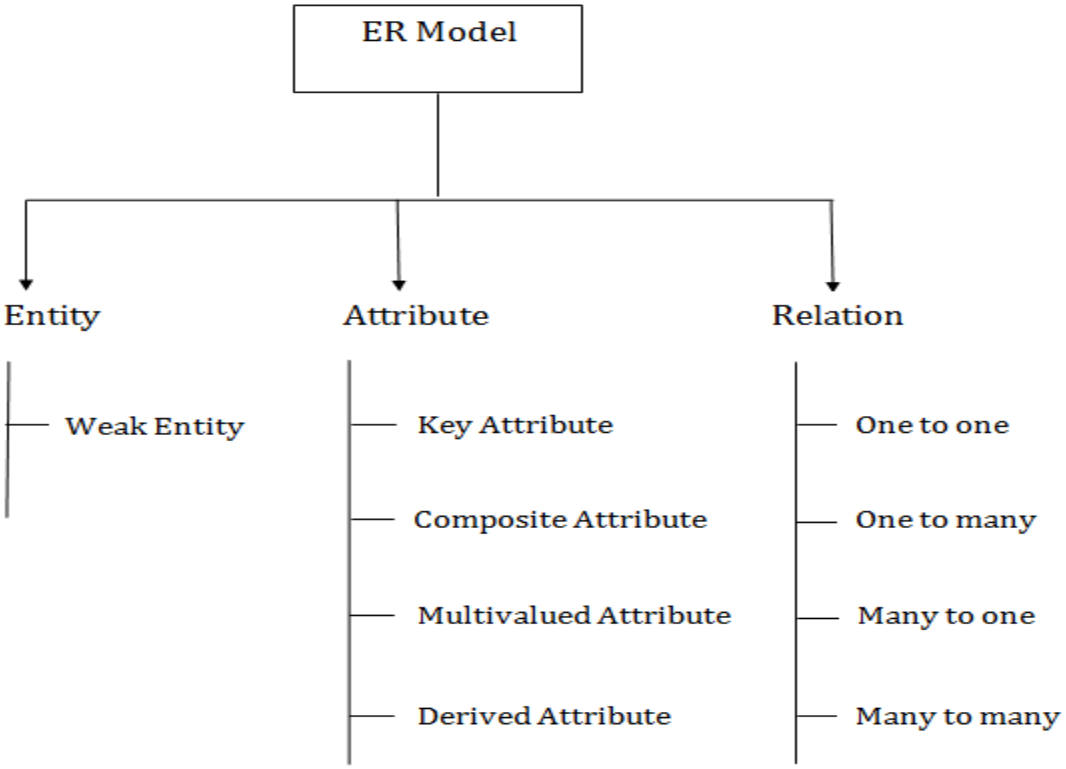
ER model

- ER model stands for an Entity-Relationship model. It is a high-level data model. This model is used to define the data elements and relationship for a specified system.
- It develops a conceptual design for the database. It also develops a very simple and easy to design view of data.
- In ER modeling, the database structure is portrayed as a diagram called an entity-relationship diagram.

For example, Suppose we design a school database. In this database, the student will be an entity with attributes like address, name, id, age, etc. The address can be another entity with attributes like city, street name, pin code, etc and there will be a relationship between them.



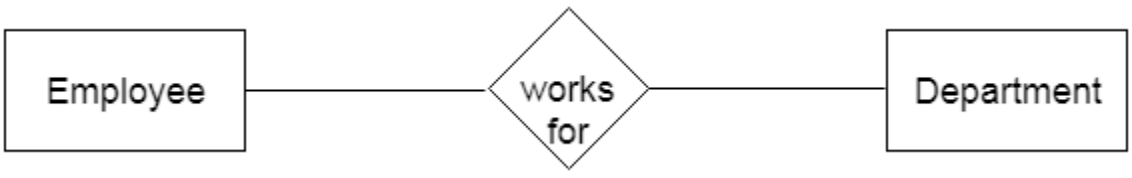
Component of ER Diagram



1. Entity:

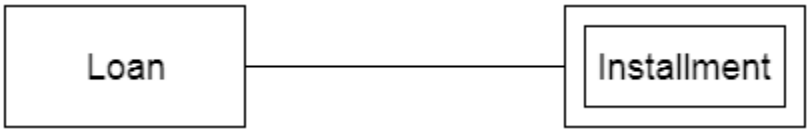
An entity may be any object, class, person or place. In the ER diagram, an entity can be represented as rectangles.

Consider an organization as an example- manager, product, employee, department etc. can be taken as an entity.



a. Weak Entity

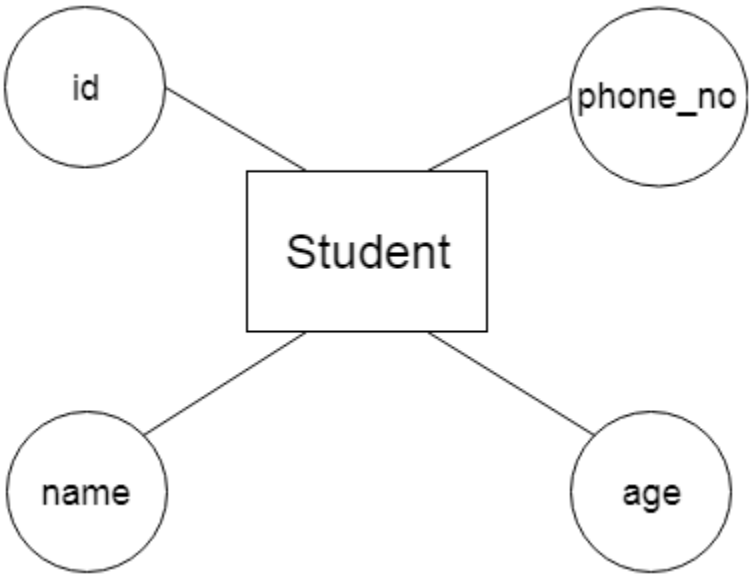
An entity that depends on another entity called a weak entity. The weak entity doesn't contain any key attribute of its own. The weak entity is represented by a double rectangle.



2. Attribute

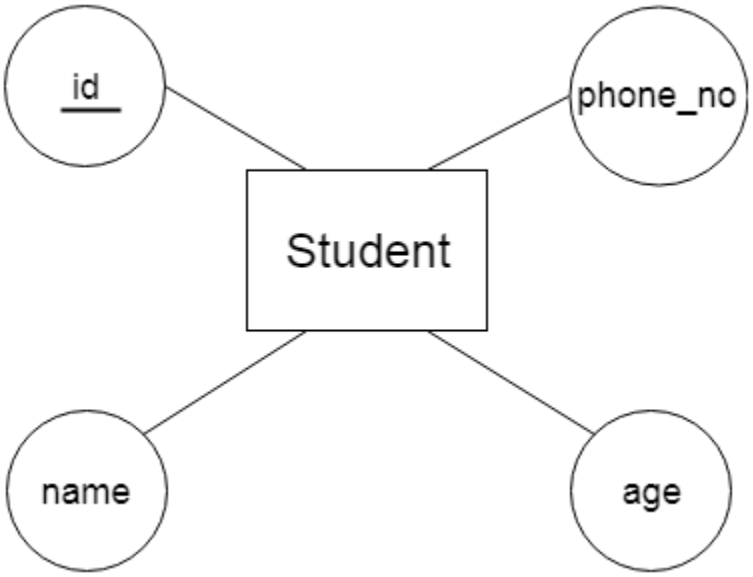
The attribute is used to describe the property of an entity. Eclipse is used to represent an attribute.

For example, id, age, contact number, name, etc. can be attributes of a student.



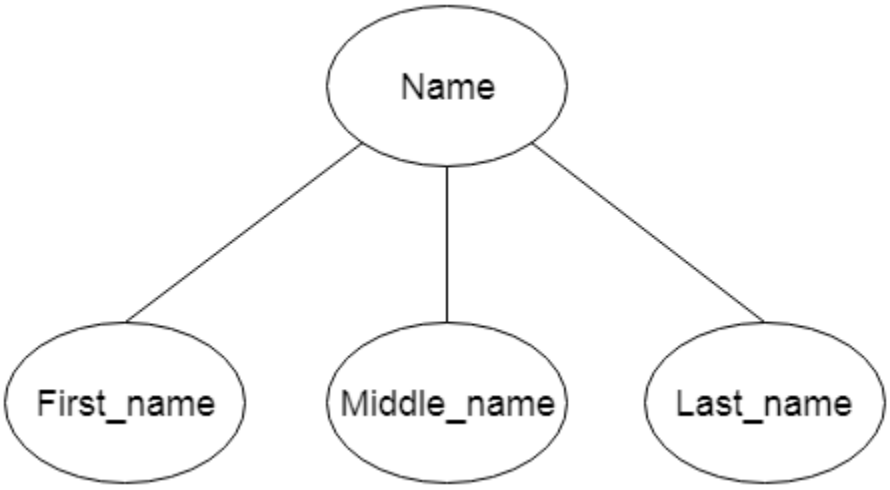
a. Key Attribute

The key attribute is used to represent the main characteristics of an entity. It represents a primary key. The key attribute is represented by an ellipse with the text underlined.



b. Composite Attribute

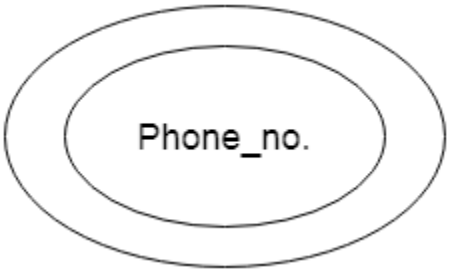
An attribute that composed of many other attributes is known as a composite attribute. The composite attribute is represented by an ellipse, and those ellipses are connected with an ellipse.



c. Multivalued Attribute

An attribute can have more than one value. These attributes are known as a multivalued attribute. The double oval is used to represent multivalued attribute.

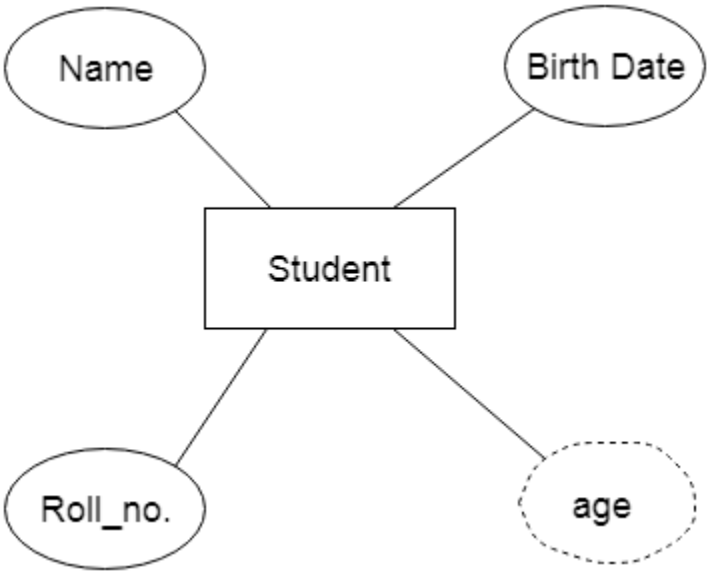
For example, a student can have more than one phone number.



d. Derived Attribute

An attribute that can be derived from other attribute is known as a derived attribute. It can be represented by a dashed ellipse.

For example, A person's age changes over time and can be derived from another attribute like Date of birth.



3. Relationship

A relationship is used to describe the relation between entities. Diamond or rhombus is used to represent the relationship.

Types of relationship are as follows:

a. One-to-One Relationship

When only one instance of an entity is associated with the relationship, then it is known as one to one relationship.

For example, A female can marry to one male, and a male can marry to one female.

b. One-to-many relationship

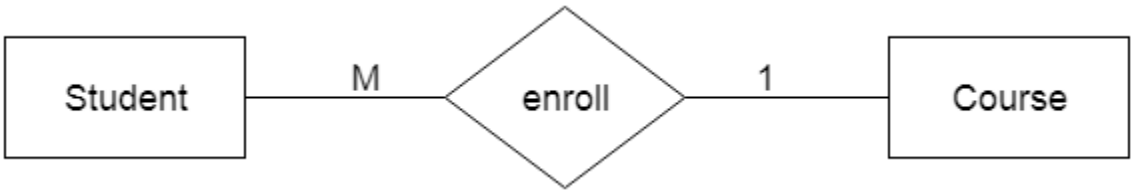
When only one instance of the entity on the left, and more than one instance of an entity on the right associates with the relationship then this is known as a one-to-many relationship.

For example, Scientist can invent many inventions, but the invention is done by the only specific scientist.

c. Many-to-one relationship

When more than one instance of the entity on the left, and only one instance of an entity on the right associates with the relationship then it is known as a many-to-one relationship.

For example, Student enrolls for only one course, but a course can have many students.



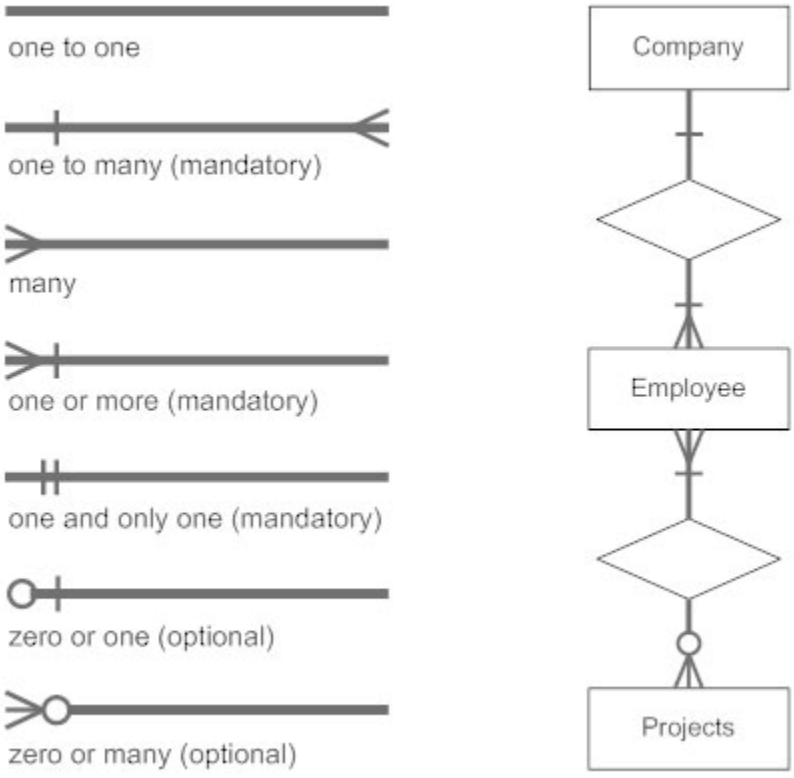
d. Many-to-many relationship

When more than one instance of the entity on the left, and more than one instance of an entity on the right associates with the relationship then it is known as a many-to-many relationship.

For example, Employee can assign by many projects and project can have many employees.

Notation of ER diagram

Database can be represented using the notations. In ER diagram, many notations are used to express the cardinality. These notations are as follows:

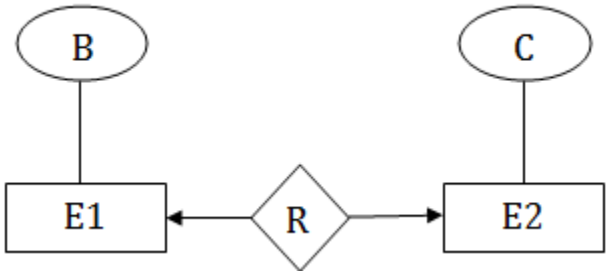


Mapping Constraints

- A mapping constraint is a data constraint that expresses the number of entities to which another entity can be related via a relationship set.
- It is most useful in describing the relationship sets that involve more than two entity sets.
- For binary relationship set R on an entity set A and B, there are four possible mapping cardinalities. These are as follows:
    1. One to one (1:1)
    2. One to many (1:M)
    3. Many to one (M:1)
    4. Many to many (M:M)

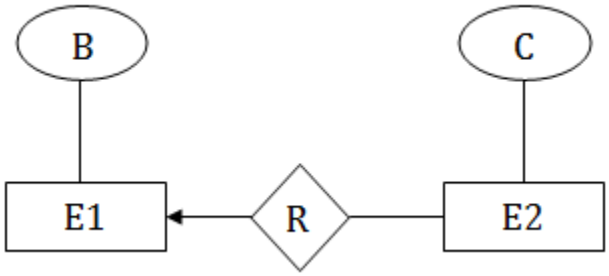
One-to-one

In one-to-one mapping, an entity in E1 is associated with at most one entity in E2, and an entity in E2 is associated with at most one entity in E1.



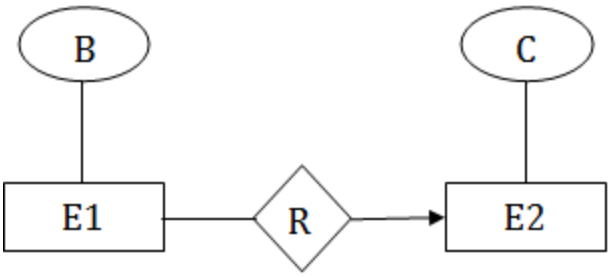
One-to-many

In one-to-many mapping, an entity in E1 is associated with any number of entities in E2, and an entity in E2 is associated with at most one entity in E1.



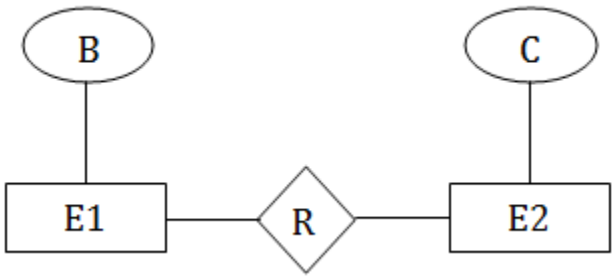
Many-to-one

In one-to-many mapping, an entity in E1 is associated with at most one entity in E2, and an entity in E2 is associated with any number of entities in E1.



Many-to-many

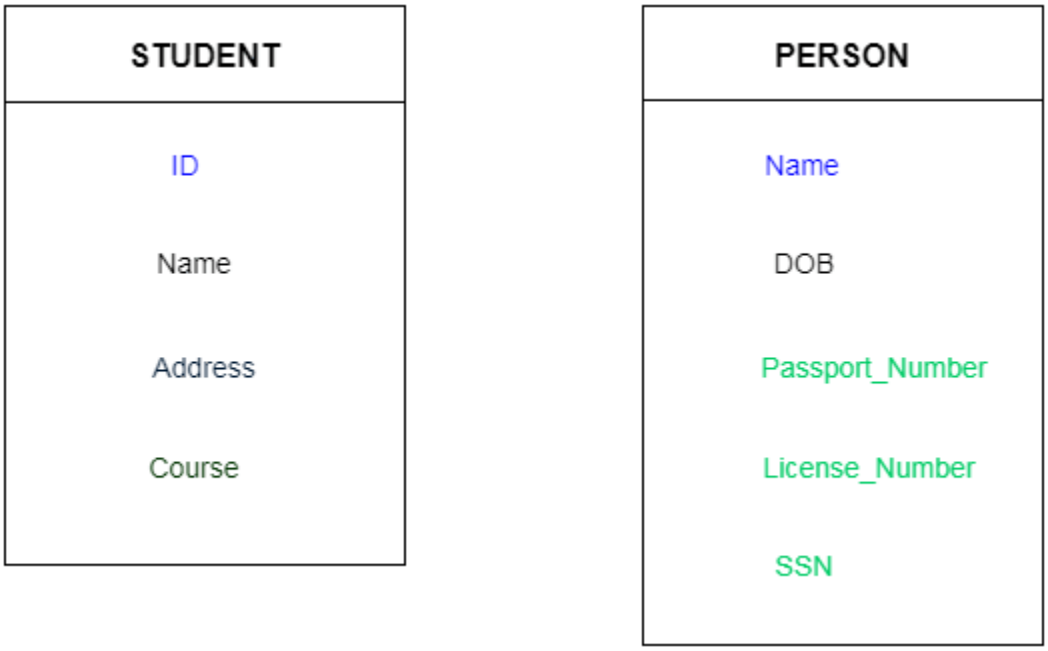
In many-to-many mapping, an entity in E1 is associated with any number of entities in E2, and an entity in E2 is associated with any number of entities in E1.



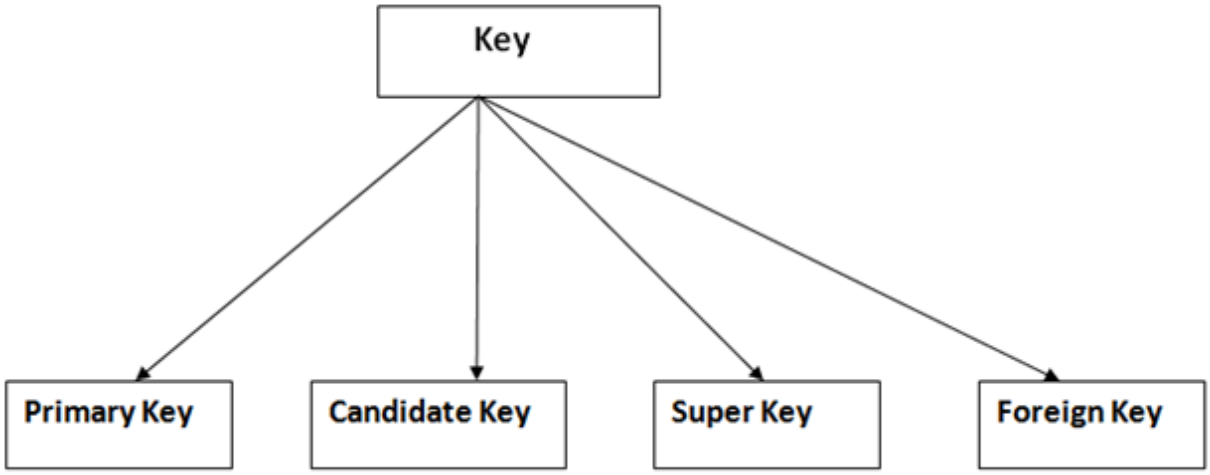
Keys

- Keys play an important role in the relational database.
- It is used to uniquely identify any record or row of data from the table. It is also used to establish and identify relationships between tables.

For example: In Student table, ID is used as a key because it is unique for each student. In PERSON table, passport_number, license_number, SSN are keys since they are unique for each person.

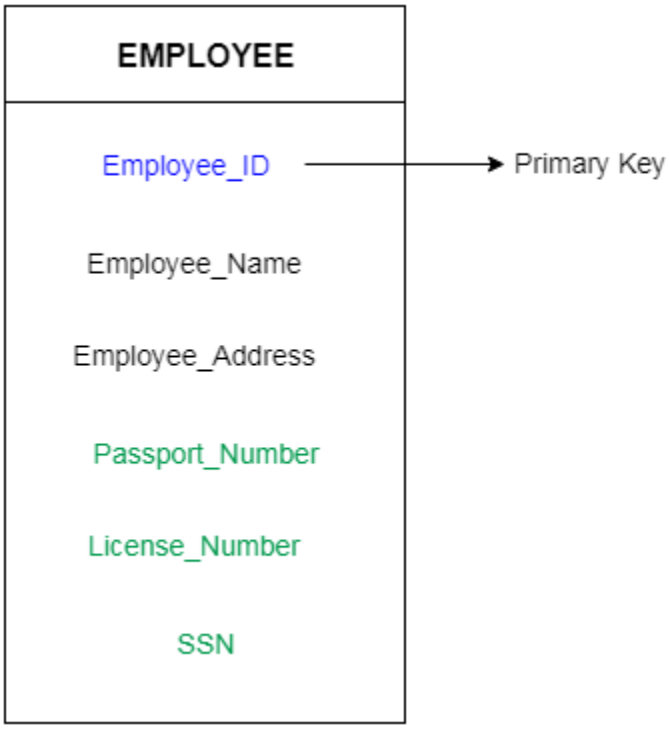

STUDENT
ID
Name
Address
Course
PERSON
Name
DOB
Passport_Number
License_Number
SSN

Types of key:


Key
Primary Key
Candidate Key
Super Key
Foreign Key

1. Primary key

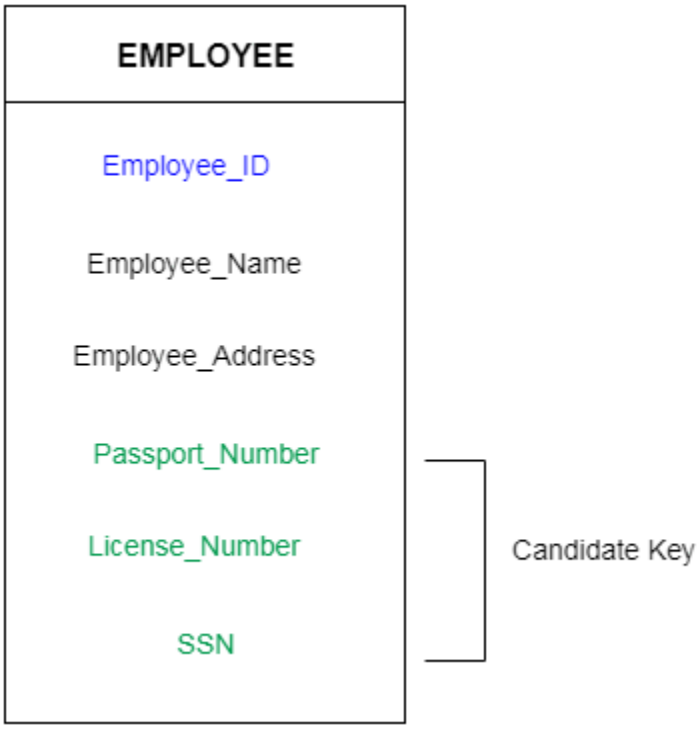
- It is the first key which is used to identify one and only one instance of an entity uniquely. An entity can contain multiple keys as we saw in PERSON table. The key which is most suitable from those lists become a primary key.
- In the EMPLOYEE table, ID can be primary key since it is unique for each employee. In the EMPLOYEE table, we can even select License_Number and Passport_Number as primary key since they are also unique.
- For each entity, selection of the primary key is based on requirement and developers.



2. Candidate key

- A candidate key is an attribute or set of an attribute which can uniquely identify a tuple.
- The remaining attributes except for primary key are considered as a candidate key. The candidate keys are as strong as the primary key.

For example: In the EMPLOYEE table, id is best suited for the primary key. Rest of the attributes like SSN, Passport_Number, and License_Number, etc. are considered as a candidate key.



3. Super Key

Super key is a set of an attribute which can uniquely identify a tuple. Super key is a superset of a candidate key.

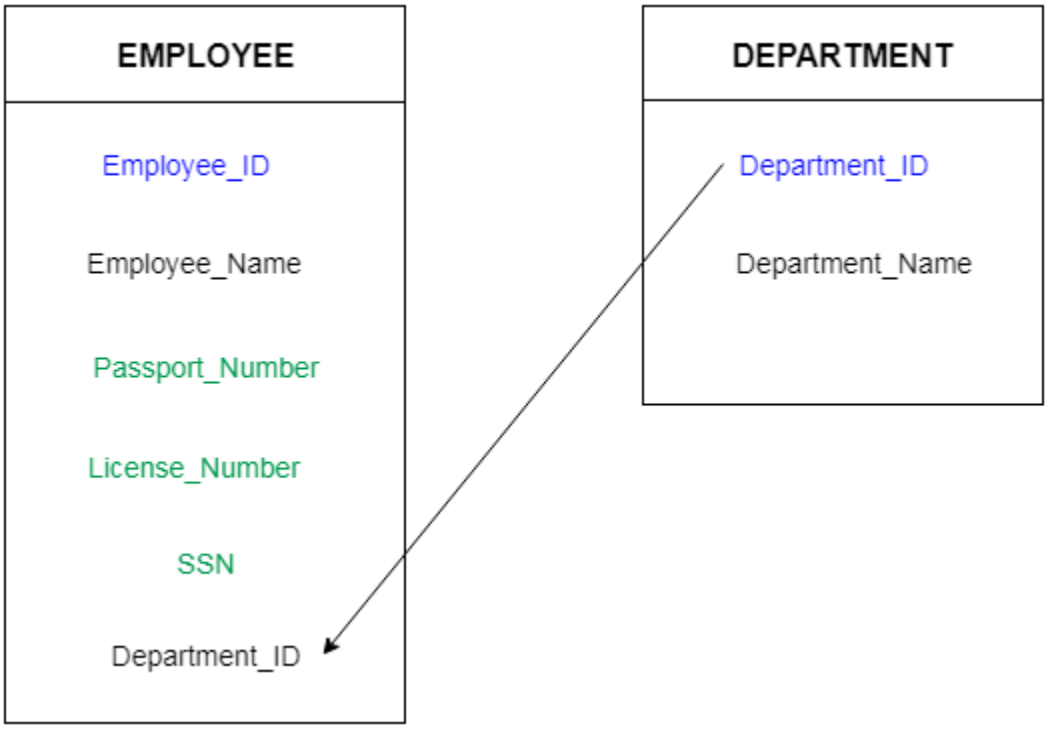
For example: In the above EMPLOYEE table, for(EMPLOEE_ID, EMPLOYEE_NAME) the name of two employees can be the same, but their EMPLYEE_ID can't be the same. Hence, this combination can also be a key.

The super key would be EMPLOYEE-ID, (EMPLOYEE_ID, EMPLOYEE-NAME), etc.

4. Foreign key

- Foreign keys are the column of the table which is used to point to the primary key of another table.
- In a company, every employee works in a specific department, and employee and department are two different entities. So we can't store the information of the department in the employee table. That's why we link these two tables through the primary key of one table.

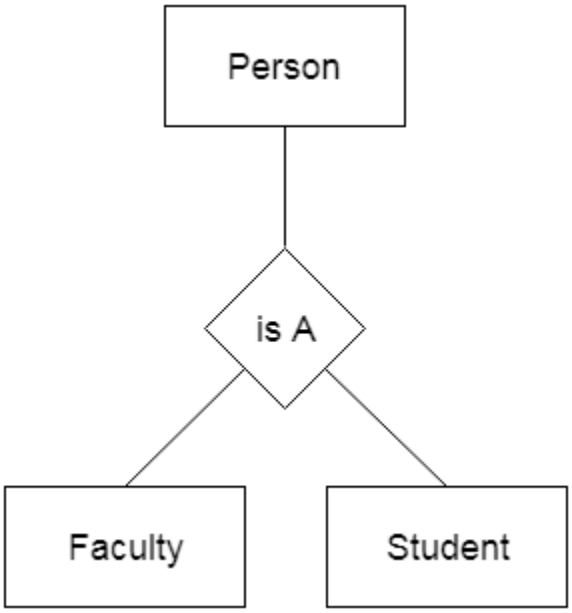
- We add the primary key of the DEPARTMENT table, Department_Id as a new attribute in the EMPLOYEE table.
- Now in the EMPLOYEE table, Department_Id is the foreign key, and both the tables are related.



Generalization

- Generalization is like a bottom-up approach in which two or more entities of lower level combine to form a higher level entity if they have some attributes in common.
- In generalization, an entity of a higher level can also combine with the entities of the lower level to form a further higher level entity.
- Generalization is more like subclass and superclass system, but the only difference is the approach. Generalization uses the bottom-up approach.
- In generalization, entities are combined to form a more generalized entity, i.e., subclasses are combined to make a superclass.

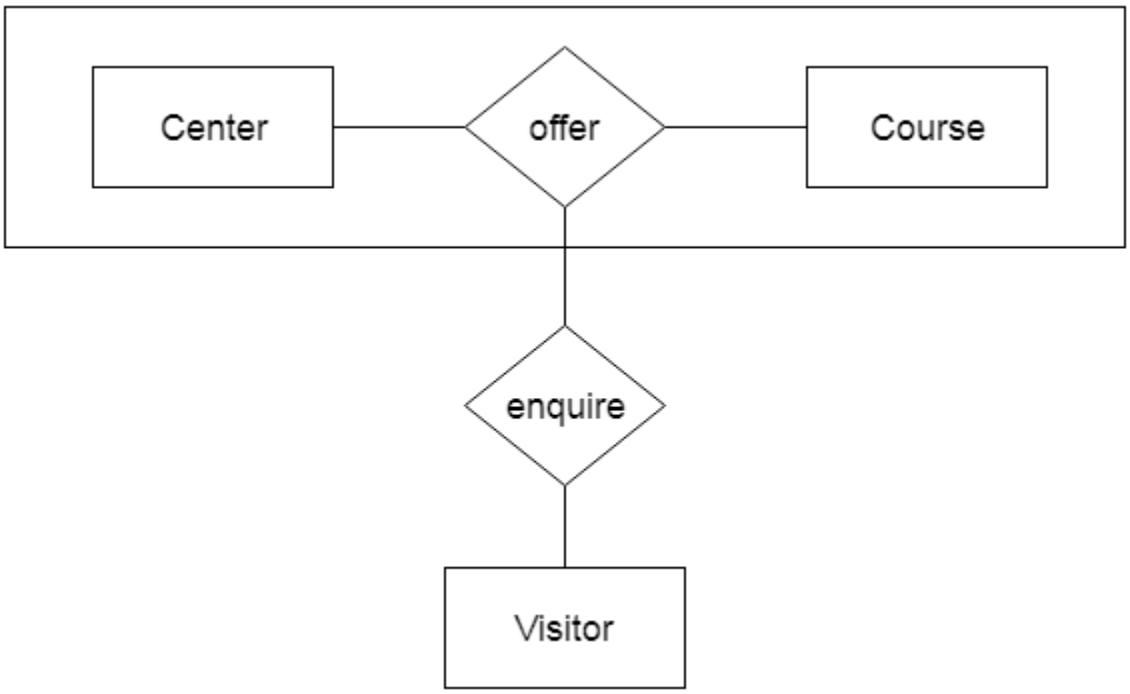
For example, Faculty and Student entities can be generalized and create a higher level entity Person.



Aggregation

In aggregation, the relation between two entities is treated as a single entity. In aggregation, relationship with its corresponding entities is aggregated into a higher level entity.

For example: Center entity offers the Course entity act as a single entity in the relationship which is in a relationship with another entity visitor. In the real world, if a visitor visits a coaching center then he will never enquiry about the Course only or just about the Center instead he will ask the enquiry about both.

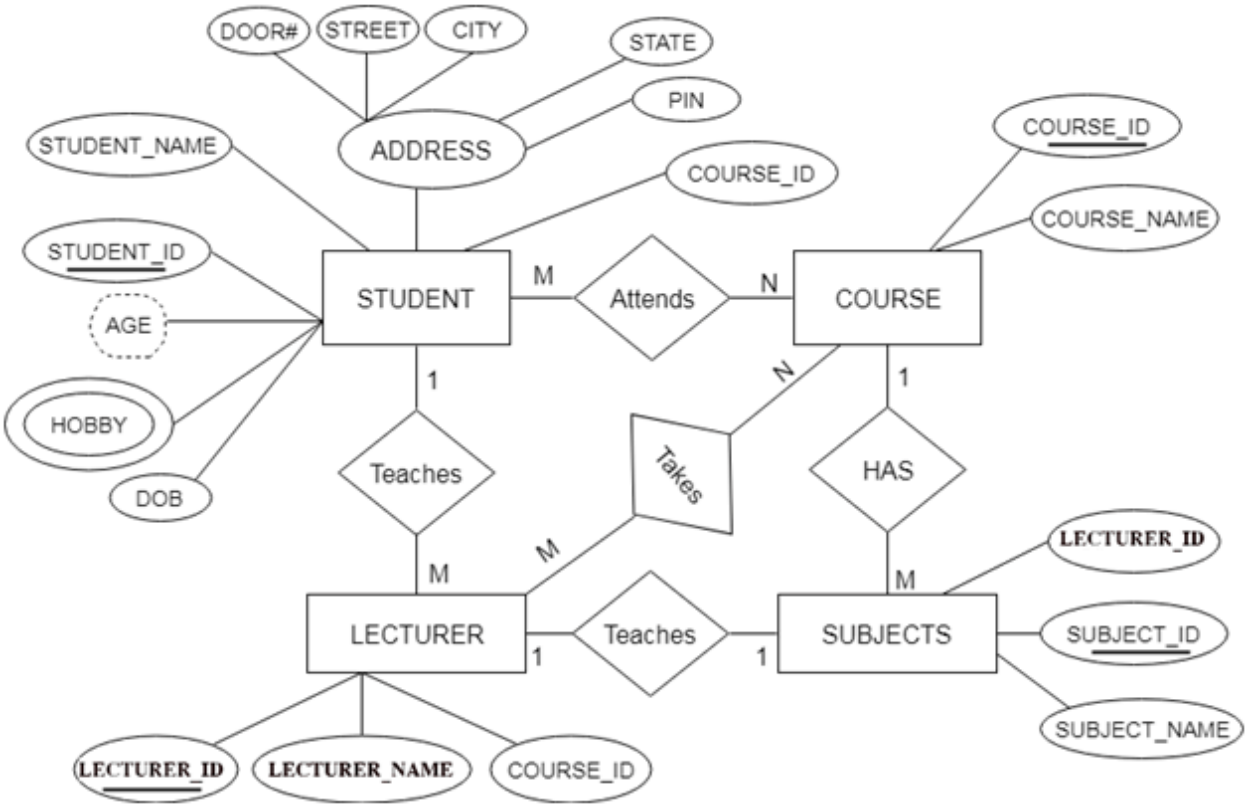


Reduction of ER diagram to Table

The database can be represented using the notations, and these notations can be reduced to a collection of tables.

In the database, every entity set or relationship set can be represented in tabular form.

The ER diagram is given below:



There are some points for converting the ER diagram to the table:

- **Entity type becomes a table.**

In the given ER diagram, LECTURE, STUDENT, SUBJECT and COURSE forms individual tables.

- **All single-valued attribute becomes a column for the table.**

In the STUDENT entity, STUDENT_NAME and STUDENT_ID form the column of STUDENT table. Similarly, COURSE_NAME and COURSE_ID form the column of COURSE table and so on.

- **A key attribute of the entity type represented by the primary key.**

In the given ER diagram, COURSE_ID, STUDENT_ID, SUBJECT_ID, and LECTURE_ID are the key attribute of the entity.

- **The multivalued attribute is represented by a separate table.**

In the student table, a hobby is a multivalued attribute. So it is not possible to represent multiple values in a single column of STUDENT table. Hence we create a table STUD_HOBBY with column name STUDENT_ID and HOBBY. Using both the column, we create a composite key.

- **Composite attribute represented by components.**

In the given ER diagram, student address is a composite attribute. It contains CITY, PIN, DOOR#, STREET, and STATE. In the STUDENT table, these attributes can merge as an individual column.

- **Derived attributes are not considered in the table.**

In the STUDENT table, Age is the derived attribute. It can be calculated at any point of time by calculating the difference between current date and Date of Birth.

Using these rules, you can convert the ER diagram to tables and columns and assign the mapping between the tables. Table structure for the given ER diagram is as below:

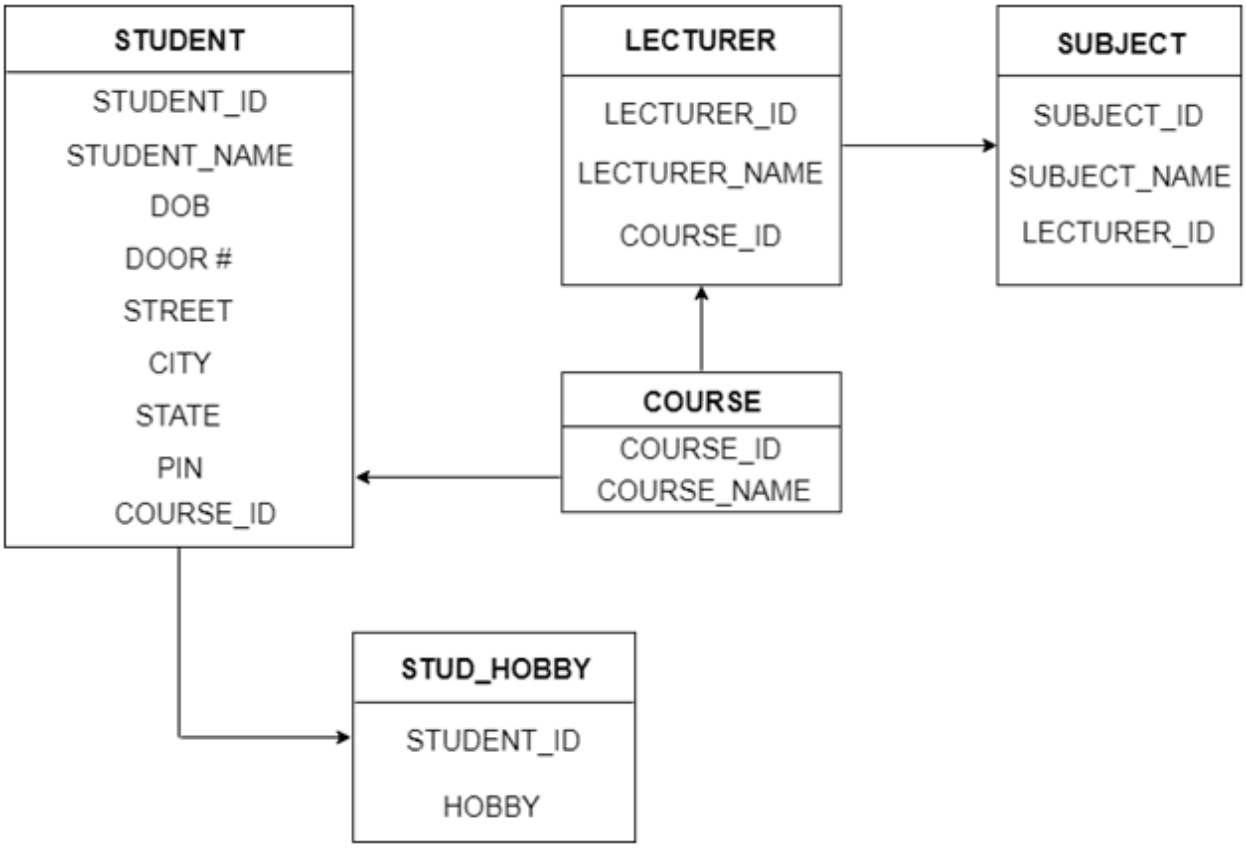


Figure: Table structure

Relationship of higher degree

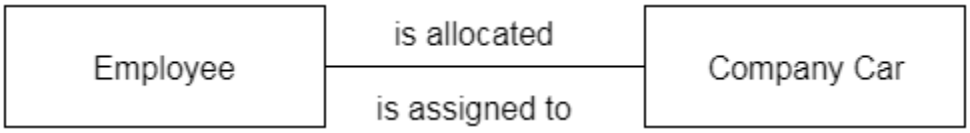
The degree of relationship can be defined as the number of occurrences in one entity that is associated with the number of occurrences in another entity.

There is the three degree of relationship:

1. One-to-one (1:1)
2. One-to-many (1:M)
3. Many-to-many (M:N)

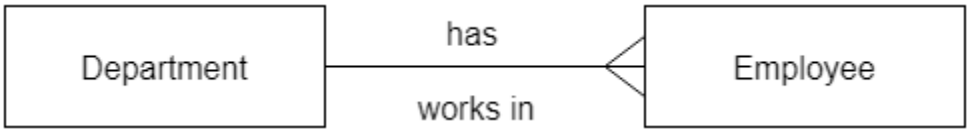
1. One-to-one

- In a one-to-one relationship, one occurrence of an entity relates to only one occurrence in another entity.
- A one-to-one relationship rarely exists in practice.
- **For example:** if an employee is allocated a company car then that car can only be driven by that employee.
- Therefore, employee and company car have a one-to-one relationship.



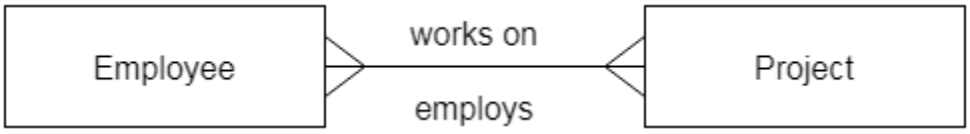
2. One-to-many

- In a one-to-many relationship, one occurrence in an entity relates to many occurrences in another entity.
- **For example:** An employee works in one department, but a department has many employees.
- Therefore, department and employee have a one-to-many relationship.



3. Many-to-many

- In a many-to-many relationship, many occurrences in an entity relate to many occurrences in another entity.
- Same as a one-to-one relationship, the many-to-many relationship rarely exists in practice.
- **For example:** At the same time, an employee can work on several projects, and a project has a team of many employees.
- Therefore, employee and project have a many-to-many relationship.



Specialization

- Specialization is a top-down approach, and it is opposite to Generalization. In specialization, one higher level entity can be broken down into two lower level entities.
- Specialization is used to identify the subset of an entity set that shares some distinguishing characteristics.
- Normally, the superclass is defined first, the subclass and its related attributes are defined next, and relationship set are then added.

For example: In an Employee management system, EMPLOYEE entity can be specialized as TESTER or DEVELOPER based on what role they play in the company.